

Build the LodeRunner Delta Trike

Another Atomic Zombie™ Extreme Machines Adventure



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About the LodeRunner Delta Trike

The LodeRunner is comfortable and rugged all purpose vehicle designed to combat the ever increasing price of gasoline, while at the same time giving its pilot a great low impact workout. Because the seat is at a height similar to that of an automobile, the LodeRunner is easy to get into and puts you at eye level to many motorized vehicles on streets and roads. The LodeRunner weighs under 80 pounds fully built, which is less than a single truck wheel, yet it can easily carry a load of 500 pounds. Stopping power is smooth and complete due to dual rear disc brakes, and the handling characteristics are predictable and smooth.

The LodeRunner is also easy and inexpensive to make, since it requires only a few small machined parts, using common hardware and cycle components. You will require only a basic welder, an angle grinder, hand drill, and the usual hand tools in order to create you own LodeRunner trike. Thanks to the simple single boom flat frame, you can easily modify the width or length of the LodeRunner to modify it to your own needs. The LodeRunner could easily become a fully faired velocar or a pedicab, or a multirider vehicle, or just about any other human or electric assisted vehicle you can imagine.

Are you ready to kick the petrol addiction and put your legs to work?
Great – let's get started!

Building the Rear Frame Box



Figure 1 – Tubing sections for the rear frame box

Most of the LodeRunner frame is made from 2 inch diameter mild steel square tubing with a 1/16 inch wall thickness. This tubing can be ordered from most steel suppliers and is very easy to cut and weld. Steel suppliers like to rate tubing wall thickness using a gage number, so 1/16 wall tubing will be called 16 gage tubing, and although there is a slight difference between the two, your best bet is to tell them you want a length of 1.5 inch square tubing with a wall thickness as close to .0625 inch (1/16) as you can get. Round tubing should be avoided for this project, as it would be impossible to align the rear axles properly and would be extremely difficult to weld correctly.

The rear of the LodeRunner includes a 24 inch square “flatbed” frame that makes it easy to drop on a cargo box or a simple board in order to carry your cargo. This square frame carries the majority of the cargo weight, and places the rear axles, disc brakes and transmission under the top of the cargo area so there is no interference with the cargo carried over the frame. So, you can easily adapt any type of load carrying bed or box and simply bolt it to the frame, without having to worry if the disc brakes or chain will get in the way.

Cut four 24 inch long sections of the 2 inch square tubing as shown in Figure 1. Each end is then cut inward at 45 degrees so that all four pieces will form a frame similar to how a picture frame is made. If you do not have a 45 degree square (recommended), then you can get the 45 degree angle by folding

a piece of paper in half. You can cut the tubing with a chop saw, zip disc, or hacksaw. I always use a zip disc to cut all of my tubing, even the most complex angles.

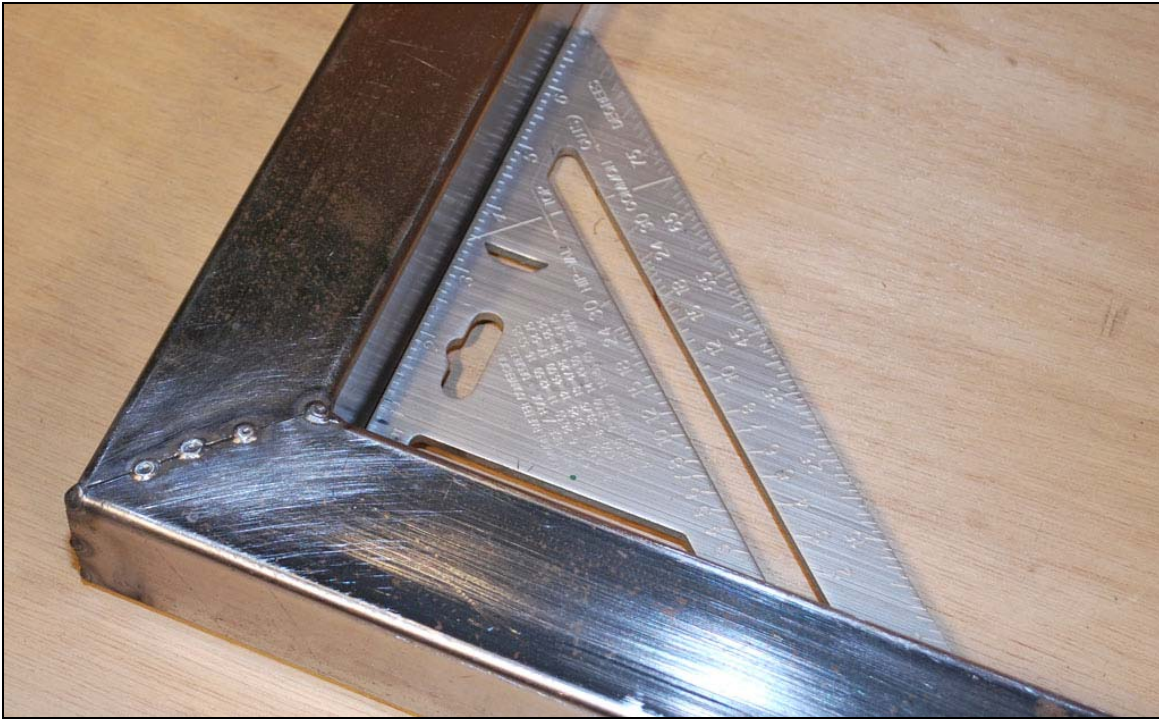


Figure 2 – Making a 24 inch square frame

The best way to ensure that the rear of your frame is square is to lay all four tubes on a flat surface, then use your 90 degree square as shown in Figure 2. A single tack weld is only needed at each corner until you can check each corner, ensuring that it forms a 90 degree angle. Add another tack weld in the center of each joint, and then check all 4 angles again. If your frame is not square, it will be easy to force it into shape while there are only a few tack welds holding it together.



Figure 3 – Check all four corners for 90 degrees

Keep adding tack welds to the top of the joint as you check each corner for 90 degrees. With four tack welds holding each joint, your square frame should be rigid enough to handle. Tilt the frame upward so you can look at the edge of the tube in front of you, comparing it with the one on the opposite side. The tubes should be parallel with each other as long as the surface you were welding on was indeed flat. If your frame seems “warped”, then you can probably bang it back into shape by hitting it with a rubber mallet or block of wood.



Figure 4 – Welding the joint corners

The joint corners are welded next (Figure 4) after ensuring that all four corners are at 90 degrees and that the frame is not warped. The frame will now be held solid by the corner welds, and because the welds are at the corners of the frame, no heat distortion will be introduced, which is why they are done next. The order of operations is very important when welding a joint because cooling weld metal tends to contract, which can cause alignment problems. If you weld the most critical side of a joint last, distortion is kept to a minimum.

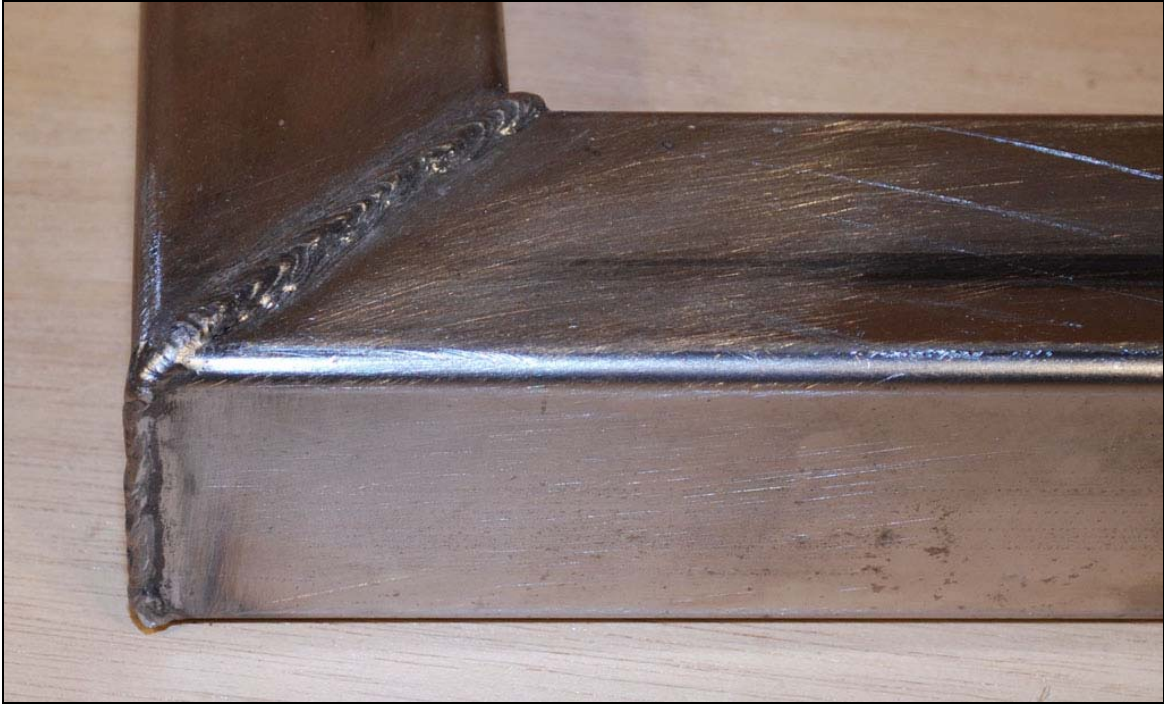


Figure 5 – Complete all of the top welds

Once all four corners are welded, complete all eight top side welds as shown in Figure 5. Work around the frame, welding the next joint to the right or left of the previous one and then flip the frame over and complete the other side in the same order. When you are finished welding and the tubing has cooled, check the 90 degree corners to ensure they are still within a few degrees.



Figure 6 – Inside corners are always done last

Since the inside corner of a joint will always be the most problematic when introducing heat distortion, it is always done last (Figure 6). Use the smallest possible bead of weld you can, keeping contraction to a minimum. The inside corner does nothing except keep out moisture, so it does not need to be a large weld – just enough to seal the joint.

Building Rear and Main BoomTube



Figure 7 – Setting up the rear and main boom tube

Figure 7 shows the completely welded rear frame box along with a new tube called the main boom. The main boom will carry the seat, bottom bracket and join the front of the frame to the rear of the frame. The bottom bracket can be adjusted along the main boom to accommodate riders of varying leg lengths, which allows the LodeRunner to be setup efficiently to practically any size rider. The main boom is a length of 2 inch square tubing cut to a length of 58 inches. If you are over 6 feet tall, then cut a 60 inch length of tubing for the main boom, just to make sure your feet clear the front tire when making sharp turns.

Tack weld the main boom directly in the center of the rear frame box as shown in Figure 7. I have the boom and rear frame tubing supported by a few equal sized buckets, as it is easier to work at this height than directly on the ground. Remember to ensure that the surface you are working on is flat and level, or your frame will not be straight. Also, the 90 degree square should be used to ensure that the angle formed between the main boom and rear frame tubing is 90 degrees. Place a good solid tack weld in the center of the joint.

Building Truss Tubes



Figure 8 – Truss tubes to support the main boom

Before you complete any welding on the main boom joint, a pair of truss tubes will be installed to aid in the welding and alignment process. The main boom is very long, so any slight side-to-side distortion from welding heat will be very noticeable, making your front wheel look misaligned with the two rear wheels. To keep the main boom at 90 degrees to the rear square, a pair of truss tubes will form triangular gussets between the boom and the rear frame tubing. Once installed, the truss tubes will make the frame a lot stronger and keep it perfectly aligned as you complete all of the welding.

The truss tubes are 7 or 8 inches long, and cut at 45 degrees on both ends, just like the frame box tubing. You can use any tubing (round or square) that between $\frac{3}{4}$ and 1 inch in diameter for these tubes. The truss tubes shown in Figure 8 are $\frac{3}{4}$ inch square tubes cut to a length of 7 inches.



Figure 9 – Installing the truss tubes

The truss tubes create a triangle between the main boom and the rear frame box as shown in Figure 9, giving the frame incredible strength. The goal is to get the truss tubes tack welded in place while the main boom is set at the perfect 90 degree angle. Once the truss tubes are solidly tack welded in place, welding heat will not affect the alignment of the main boom as you complete the joints. Figure 9 shows the top of the frame.



Figure 10 – Ready to weld the main boom

The underside of the frame is shown in Figure 10. Notice that the tack welded truss tubes are flush with the bottom of the frame tubing. At this point, the main boom is forming a perfect 90 degree angle with the rear frame box, so the main boom joints can all be welded without risk of heat distortion.



Figure 11 – Welding the tops of the joints

It is always good practice to weld in the order that fights distortion, so the top sides of the main boom and truss tubes are welded first as shown in Figure 11. An experienced welder knows instinctively which side to weld first and may even use distortion as an advantage to fix a misaligned frame. “Using the force” is not just a rule for Jedi knights!



Figure 12 – Main boom and truss tubes welded

The side joints are welded last, as these are the most critical welds when it comes to alignment. Due to the extreme strength added by the truss tubes, your main boom will stay at 90 degrees even though the weld metal will contract as it cools. Without the truss tubes in place, your main boom could be an inch or more out of alignment at the front of the frame. If you cannot weld the inside corners of the truss tube joints, then just leave them, as they do not add any strength to the frame.

Front Frame Tube and Forks



Figure 13 – Cutting the front frame tube

The front frame tube is a 15 inch long piece of the same 2 inch square tubing as the rest of the frame. Fifteen inches is more length than you will actually need, but we will be working from the ground up, deriving angles and lengths based on the parts you have chosen for this project. By working this way, you are guaranteed to get all the angles and lengths correct, even though your “donor” parts may differ from mine. Figure 13 also shows a 2 inch diameter piece of round mountain bike frame tubing for comparison. If you can find 14 or 15 inches of suitable round tubing, it could also be used, but be advised that cutting and welding round tubing is a lot more difficult.



Figure 14 – Choosing 20 inch front forks

The LodeRunner has a 20 inch front wheel, so you will need a decent pair of 20 inch front forks and a matching head tube with all of the hardware as shown in Figure 14. I hacked the head tube from an old kid's bike and found a nice beefy looking pair of BMX forks with heavy dropouts, but feel free to install whatever forks suit your taste, including suspension, if you like. The key here is to make sure that the head tube is the correct length for the fork stem, so getting both from the same donor bicycle is the easiest way to go. Even though most of the weight is near the rear of the trike, you should try to find the heaviest set of forks you can, especially if you plan to install a front hub motor later on.

Very light duty forks should be avoided for this project, and you can tell these by squeezing the ends of the fork legs together with one hand. If you can flex them a lot, then they are probably too light to be of any use. The forks shown in Figure 14 barely move when I try to crush the legs together with both hands. The dropouts are also very solid, making them perfect for a large hub motor.



Figure 15 – Checking the fork hardware

The head tube and forks do not need to be from the same source, but they do need to work together, so head tube length is important. If the head tube is too long for the fork stem, all of the hardware will not fit properly, but you can trim down the head tube. If the fork stem is too long, then you may need to find a longer head tube. Figure 15 shows all of the required fork hardware after cleaning and inspecting the bearings. Remember, bearings go into the cups “balls first”. Correctly assembled, the forks should easily spin around in the head tube with all the hardware installed.



Figure 16 – Grinding out the dropouts

When I purchased the wheels for this project, I decided to use the same strong BMX wheels all the way around, so the front fork dropouts needed to be made larger in order to take the thick 14mm axles. The 48 spoke, 14mm axle BMX wheels are almost indestructible, yet only way a fraction more than the standard 36 or 32 spoke 20 inch wheels, so I decided that a load carrying trike should have good wheels all around. To accommodate the larger front wheel axle, the two dropouts were ground wider as shown in Figure 16. This also makes it easy to drop in a front hub motor, which requires a larger dropout slot than a regular bicycle.

Creating the Head Tube



Figure 17 – Cleaning up the head tube

With a little grinder magic, the head tube can be brought back to factory new condition as shown in the left of Figure 17. I start with a rough grinding disc, and then clean up the excess frame tubing using a sanding disc (flap disc) to finish the work. Having the head tube clean is important as it will need to fit through a hole in the front frame tube as will soon be shown.

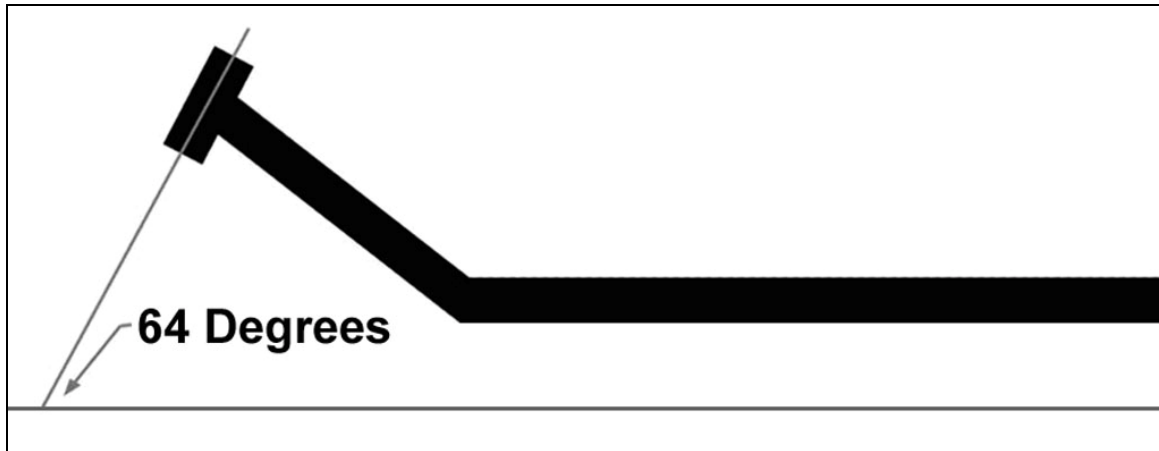


Figure 18 – Getting the ground clearance set up

The LodeRunner has a ground clearance of 15 inches as measured from the underside of the frame to the ground. This height was chosen to keep a safe stance in traffic and to allow the top of the cargo frame to clear all of the brake

and transmission parts. To make the building process easier, I will derive many of the upcoming lengths and angles directly from the frame, so find at least three objects that are 14 inches tall so the frame can be placed at the correct height.

Figure 18 shows how I propped up my frame using a few buckets and some 2 x 4s to get the required 15 inches of ground clearance.



Drawing 1 – The head tube angle is 64 degrees

The LodeRunner has a head tube angle of 64 degrees. As shown in Drawing 1, head tube angle is measured by extending a line through the center of the head tube to the ground. If you tap a long straight edge to an adjustable square and place it on the ground, it is easy to set up the head tube to the correct angle. You could also place a length of tape on a wall to use as a reference.



Figure 19 – Setting the head tube angle

The front frame tube will hold the head tube at the required 64 degree angle as shown in Figure 19. Since your head tube, front tire and forks may differ from mine, this tube is simply clamped to the frame and then marked for cutting, ensuring that your front wheel position and angle end up the same as mine, even though the parts may differ. Install your front wheel with a fully inflated tire on the forks and then have a helper hold the head tube at the required angle. The front wheel should be at least three inches away from the front end of the main boom as well.

With the wheel held in place, the front tube can then be clamped to the end of the main boom as shown in Figure 19 so that it crosses the head tube in the center. The head tube will actually pass through a hole in the front boom as will soon be shown.



Figure 20 – Marking the front frame tube for cutting

The front frame tube is welded to the top of the main boom right at the end, so a line can be drawn as shown in Figure 20 to get the angle correct. By deriving these angle cut lines this way, there will be no errors in the final frame dimensions due to a miscalculation or differing part than mine.



Figure 21 – Marking the head tube line on the front tube

The head tube passes through the front tube, so it also needs to be marked along the side of the tube as shown in Figure 21. Read ahead a few steps and you will see how these lines are used to locate the head tube holes.



Figure 22 – Marking the other head tube line

The line is drawn on both side of the head tube as shown in Figure 22. Once these lines are transferred to the top of the tube, it will be easy to create the holes that the head tube must pass through.

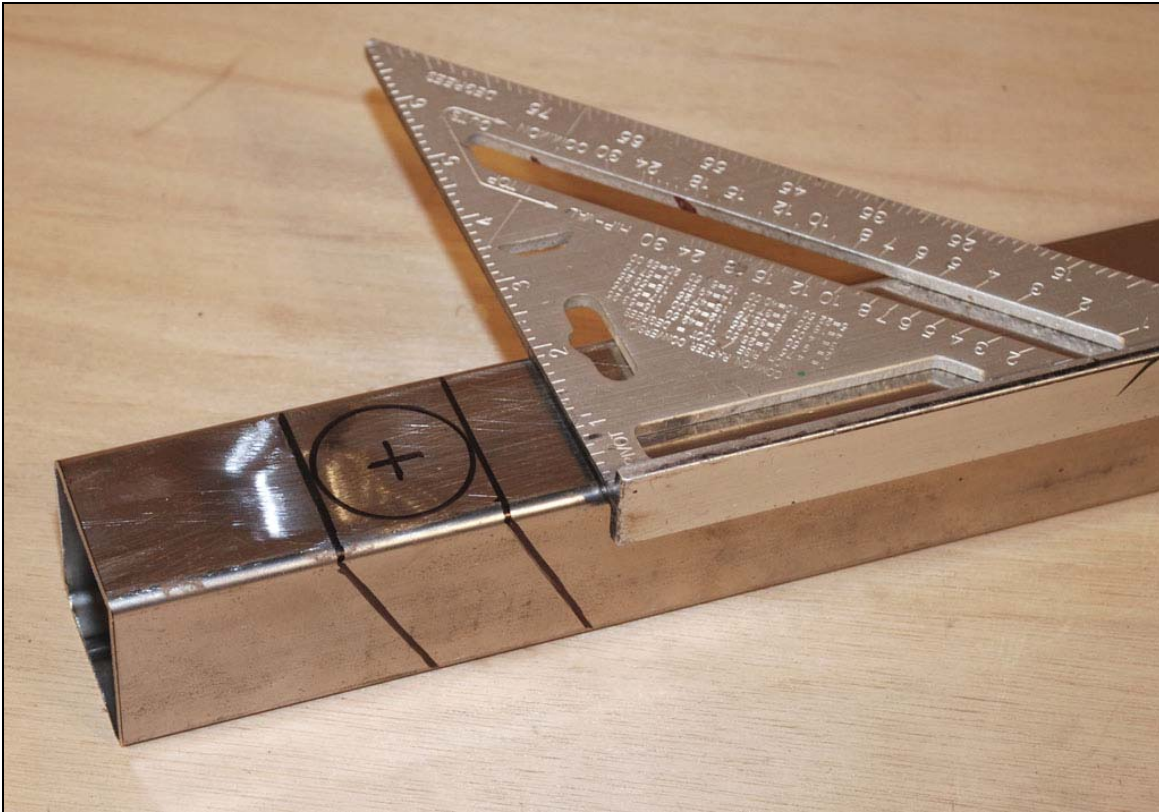


Figure 23 – Transferring the lines to the top

Using a 90 degree square, transfer the head tube lines to the top and bottom of the tube so that the correct position for the hole can be found. Using the head tube shell with cups removed; trace the hole in the center of the tube between the transferred lines as shown in Figure 23. When the holes are cut, the head tube will pass directly through the front tube and be at the required 64 degree angle. Don't worry about the extra tubing sticking out past the head tube; this will be dealt with later.

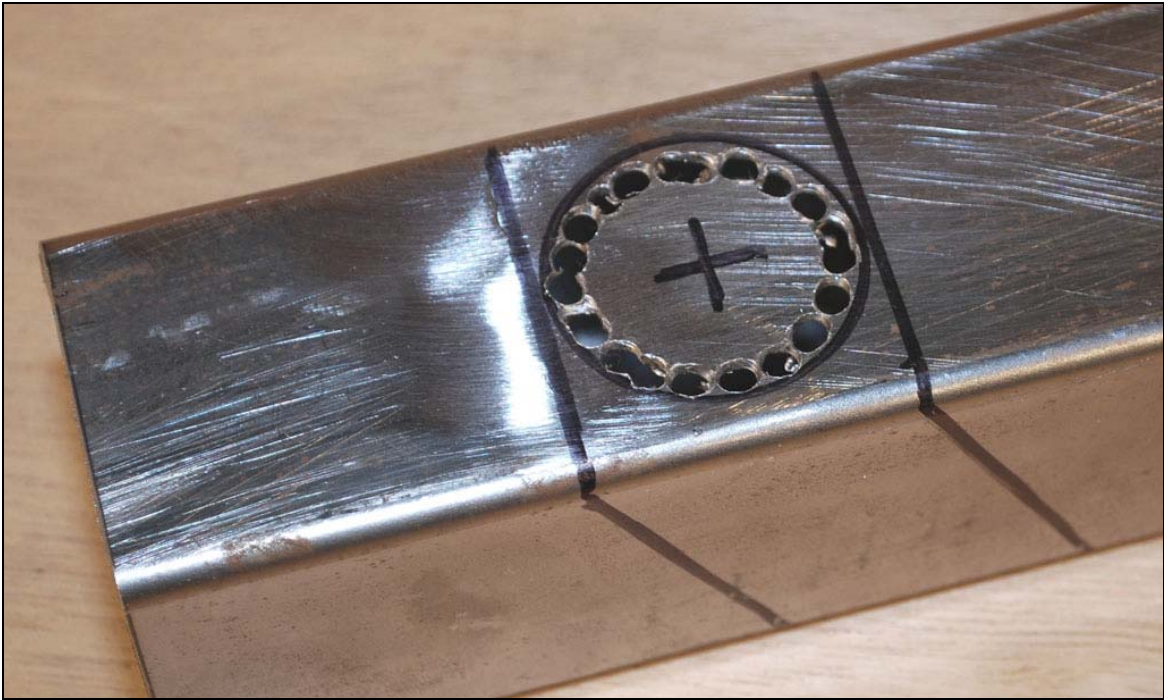


Figure 24 – Cutting holes the “Atomic Zombie” way!

For some reason, I get great satisfaction out of building things with the absolute minimal tools possible, so I don't own a drill press or even a decent hole saw. To cut a hole large enough for a head tube on the front tube, you could use the correct size hole saw, or use what I like to call the “Can Opener” method, which is easy and requires a small drill bit and a hand drill. As shown in Figure 24, you start by drilling a bunch of 1/8 inch holes along the inside of the line, trying to get them as close together as you can.

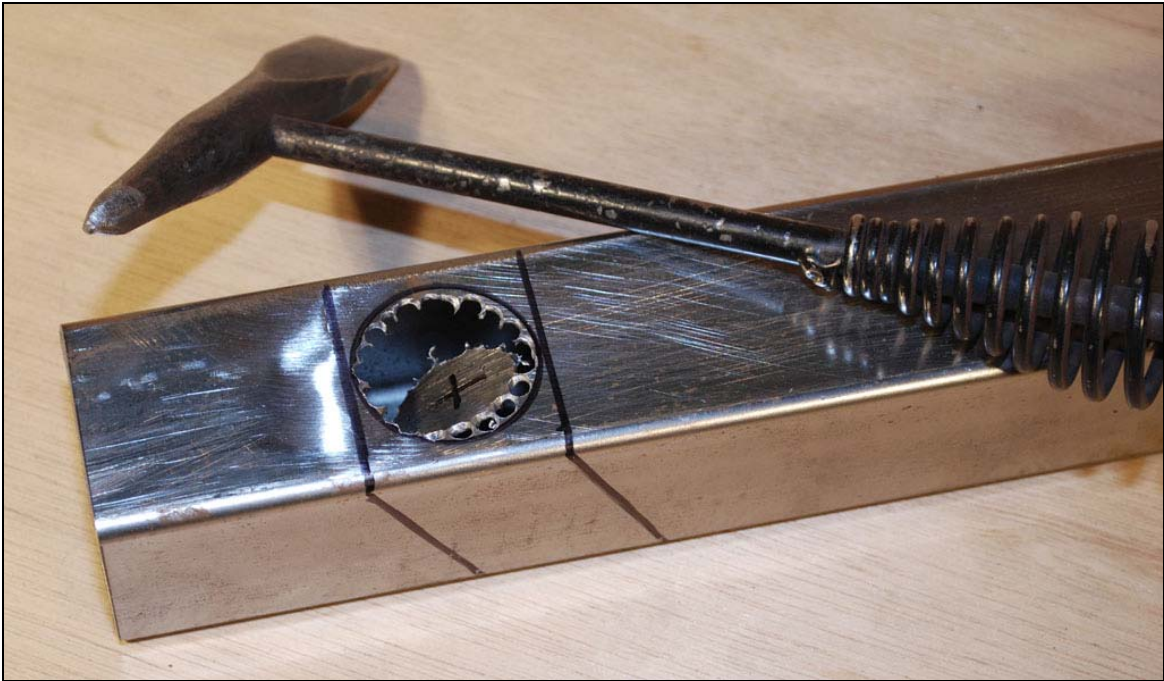


Figure 25 – The can opener method in action

After you have drilled smaller holes around the edge of the larger hole, a quick smack with a chipping hammer will remove the “lid”, just like the lid on a can. The hole looks more like a shark’s mouth at this point (Figure 25), but that’s nothing the round file won’t fix in a few minutes.



Figure 26 – Using the hand file to make the hole oval

Even if you took the lazy (logical) way out and used a hole saw on the front tube, chances are that the head tube will not pass through both holes just yet. Yes, you will need to use that round file after all! Since the head tube is on an angle, the holes need to be slightly oval in order to allow the tube to pass through both. Figure 26 shows the holes before they were made oval, and you can see the difference of you compare them to the next photo.

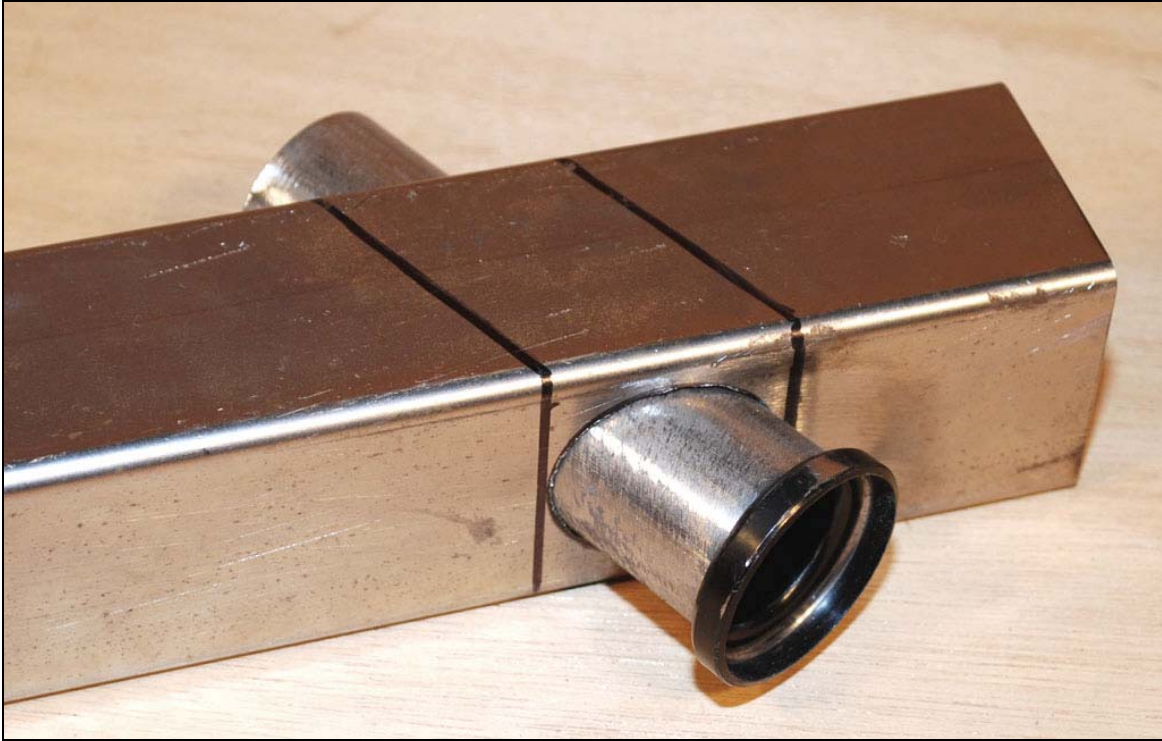


Figure 27 – The head tube fits perfectly

With a few minutes of grinding and checking, the head tube should pass perfectly through the front tube as shown in Figure 27. Because you are working the hole with a hand file, it is easy to get the head tube gap down to a minimum, which will make welding very easy.



Figure 28 – One last check before welding

After you get the head tube to pass through the holes in the front tube, drop the fork hardware back in and then test fit the tube with the main boom as shown in Figure 28. The head tube angle should be very close to the required 64 degrees. If you have not yet cut the angle at the base of the main tube, then check to make sure your lines are still correct and make the cuts. Don't worry about military precision with the head tube angle – a few degrees either way will not make any difference in the handling characteristics of the trike.



Figure 29 – Trimming and capping the open tube

The extra material extending past the head tube can be trimmed in any way you like. I decided to cut it off square, leaving 1 inch past the head tube so that I could install a headlight mount. The open end of the tube will need to be capped in order to make it rigid and to keep out moisture from rotting your frame. This frame cap must be welded and is very important for strength, so don't simply cap it off with a plastic plug.

Any similar thickness steel can be used to make a tubing cap. Figure 29 shows a cap made from cutting the wall from the leftover tube and then tack welding it in place. Also, you will do the same thing to the open end of the main boom tube, so cut out two caps and duplicate the process for both tubes.



Figure 30 – The cap is welded all the way around

Weld the tubing cap all the way around as shown in Figure 30. Don't worry about doing a fancy weld here, as it will be ground clean.



Figure 31 – Tubing cap completed

The fully welded tubing cap is then ground clean using a flap disc as shown in Figure 31. Flap discs (sanding discs) are great for cleaning up welds as they do not dig deep into the metal. A ground weld should never have a valley because that weakens the joint.



Figure 32 – Tack weld the head tube at the center

The head tube can now be placed through the front tube and tack welded at the center as shown in Figure 32. If your hole is big and sloppy, then try to get the head tube in the middle, so you can adjust it either way as needed. The head tube should extend an equal distance out of the top and bottom of the hole.



Figure 33 – Weld the front before the sides

The front of the joint should be welded before the sides as shown in Figure 33 to help combat heat distortion. When viewed from the end of the tube, the head tube should appear to pass straight through the square tubing at a perfect 90 degrees.

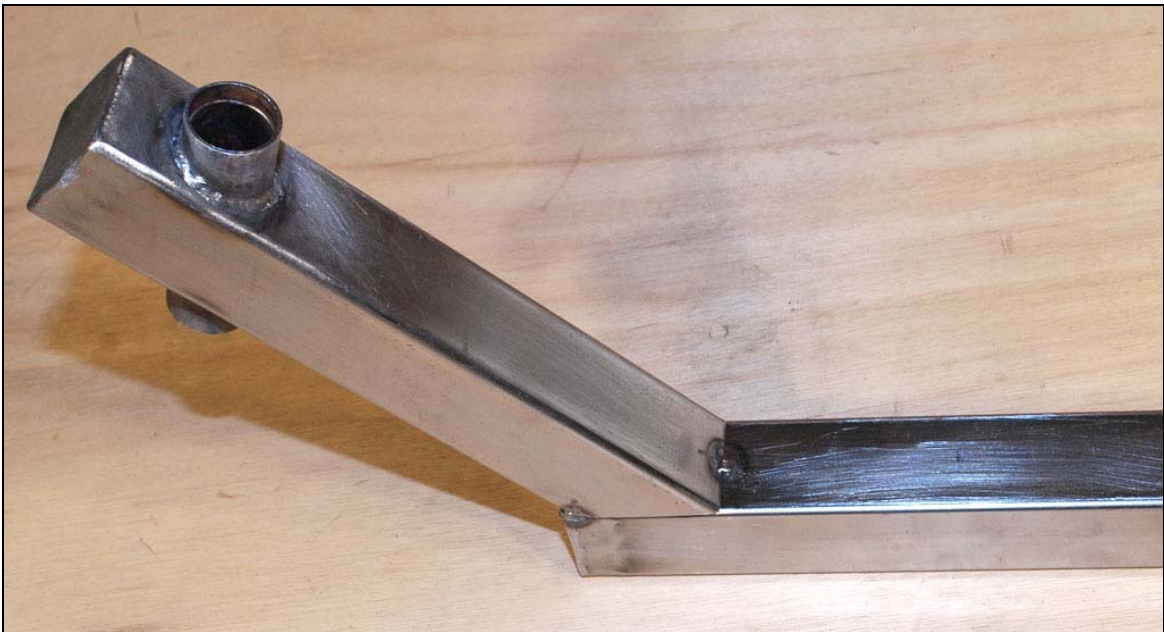


Figure 34 – Tack welding the front tube to the main boom

Once you have welded the head tube joint all the way around, drop the front tube onto the main boom and tack weld it as shown in Figure 34. You will need to install the front wheel and forks, as this is your last chance to cure any side-to-side alignment errors that may have occurred during the head tube drilling and welding process.



Figure 35 – Getting the wheel aligned

Take a look from the front of the frame with the forks and wheel installed as shown in Figure 35. If your head tube passes through the hole at an angle, you can “fudge” things a bit by tilting the front tube a bit to compensate. It’s more important that the forks are straight than if the front tube is a bit twisted, so keep this in mind as you look down the front of the trike. You can also tilt the front wheel a tiny bit in the dropouts if needed. The goal is always perfection, but it is up to you how close to perfection you need to get. If an error is obvious to you, it will also be obvious to others, so don’t be afraid to take out that grinder and fix your errors!

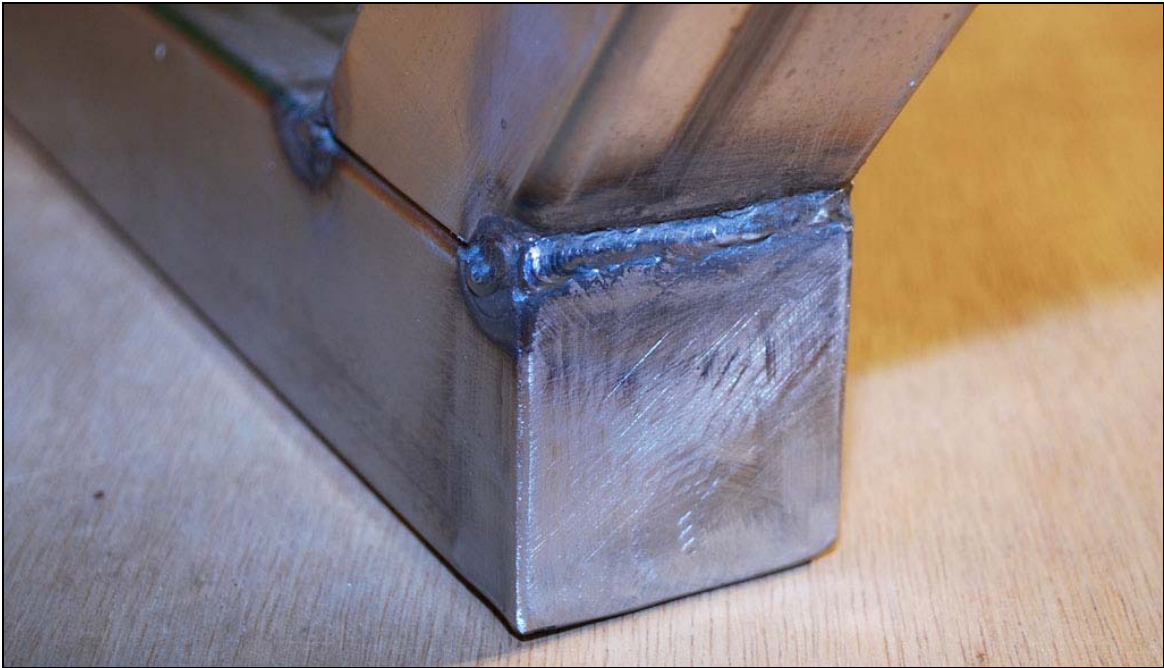


Figure 36 – Following the usual welding order

If your front wheel looks straight, then add a full bead of weld across the front and back of the joint as shown in Figure 36. Although distortion should be minimal, it won't hurt to drop the forks back in for one last check. If something moved, you could still "coax" it back into shape with a length of 2 x 4 or a large rubber mallet. A huge rubber mallet is another tool that I often use.

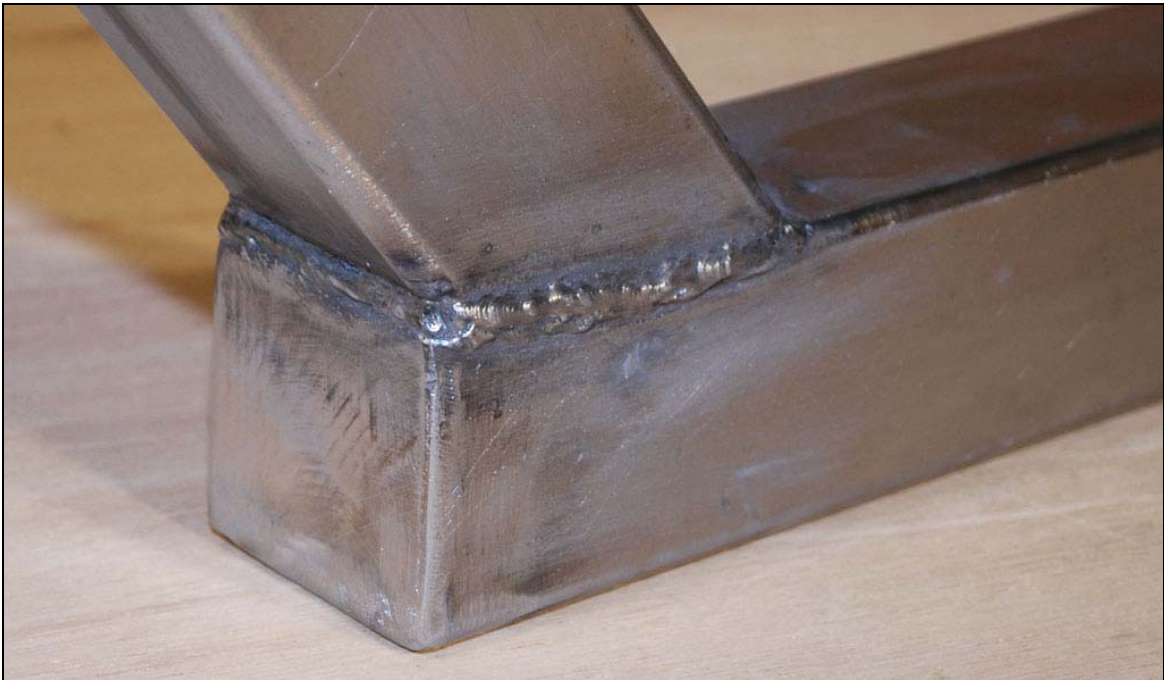


Figure 37 – Completing the front tube joint

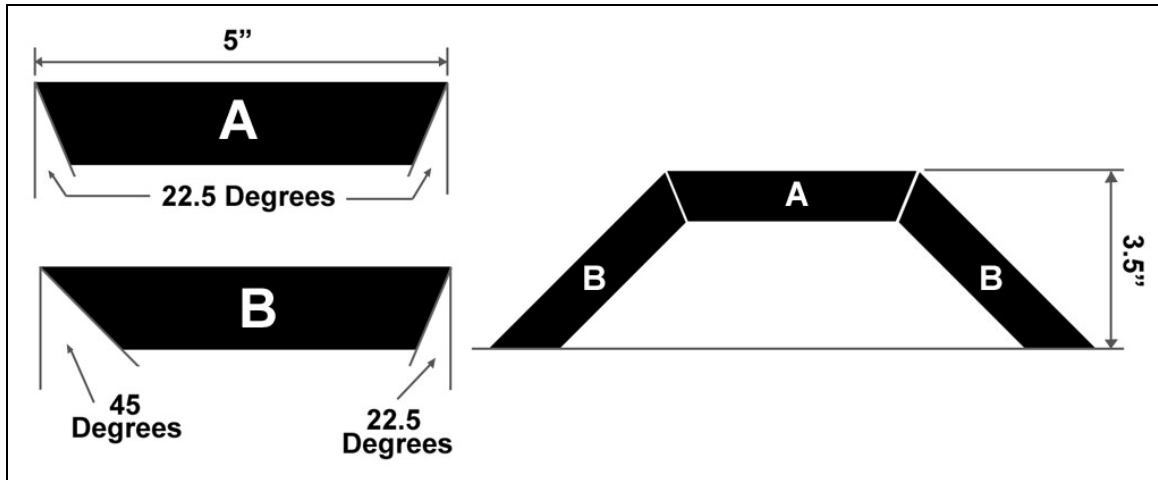
Finally, weld the sides of the front tube joint as shown in Figure 37. This weld can be safely ground flush, so don't try to be a perfectionist here, just get the joint filled.



Figure 38 – The front is now complete

Grind the weld area flush as shown in Figure 38 using a flap disc. Remember, don't take out too much of the weld metal – a small hill is much better than a small valley. Most of the force is carried by the front and rear joint, so you can grind the sides of the joint to make them look neat and clean.

Bearing Support Tubes



Drawing 2 – Bearing support tube parts

To keep the seat height up to a safe city traffic level and to keep the brake and transmission hardware out of the cargo area, the rear bearings will be placed on a pair of bearing support tubes, which are welded to the underside of the rear frame box. These tubes are made from 1 inch square tubing, which is the perfect size to support the pillow block bearings. The only goal of these bearing supports is to place the bearings 3.5 inches away from the underside of the frame. Read ahead a bit to understand how this system works.

Following drawing 2, you will need to cut two tubes marked “A” and 4 tubes marked “B” to create both bearing supports.

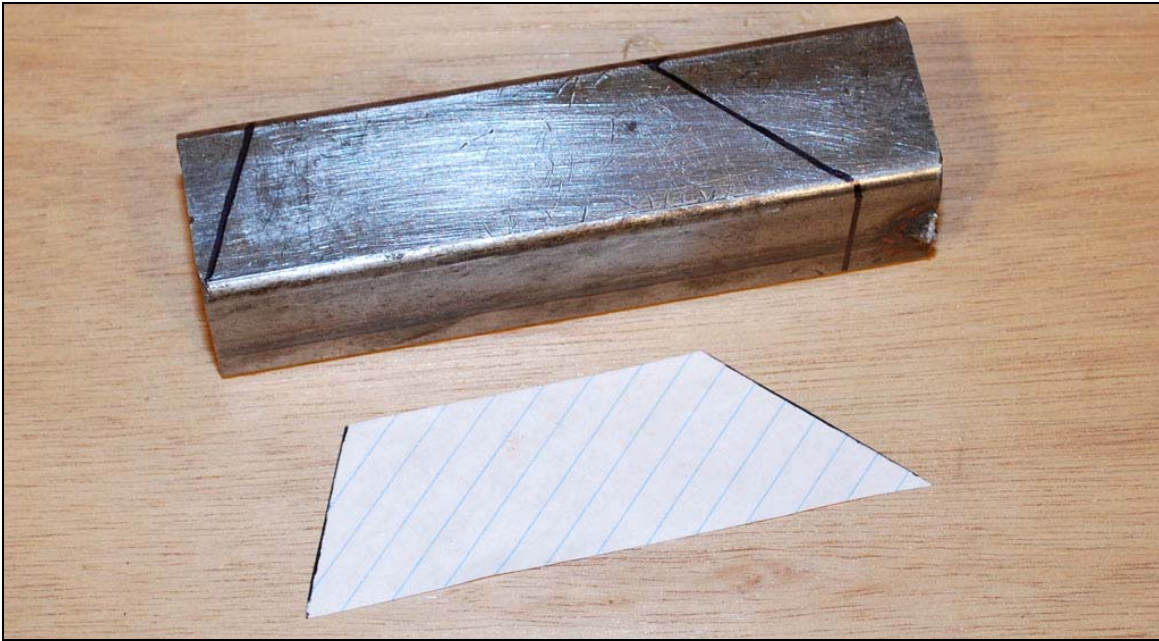


Figure 39 – making the bearing support tubes

Since 22.5 degrees is half of 45 degrees, you can probably check your angles by folding a bit of paper in half once for the 45 degree angle, and twice for the 22.5 degree angle. Don't worry too much about being perfect here, as long as both bearing supports are of equal size and are about 3.5 inches in height, they will work fine. Having both the same is more important than being perfect.

Figure 39 shows one of the tubes that will make up one of the four tubes marked "B" in Drawing 2. I used the folded paper method to check the angles.



Figure 40 – A good way to make parts the same

To make two parts equal, grind them both at the same time in the vice as shown in Figure 40. Even if you made a small error in one of the cuts, grind the other tubes the same as it is important that both bearing supports are the same height. If they are not, your trike will have a permanent tilt to one side.

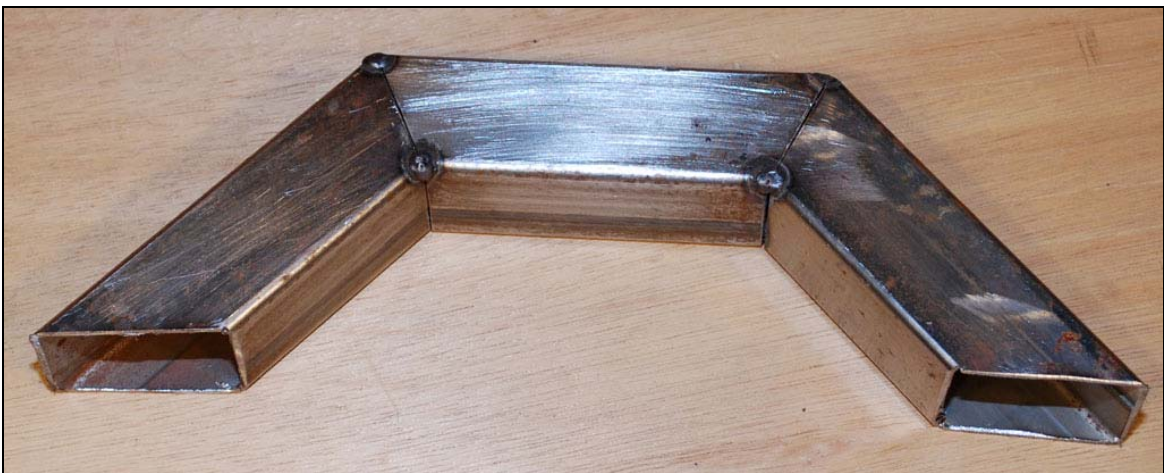


Figure 41 – One bearing support tack welded

When you are building the pair of bearing supports, make them both at the same time, and check them for equal size during each step of the way. You will probably need to place them both in the vice and do some grinding to make

them exactly the same height later. Figure 41 shows one of the supports after tack welding the three pieces together.

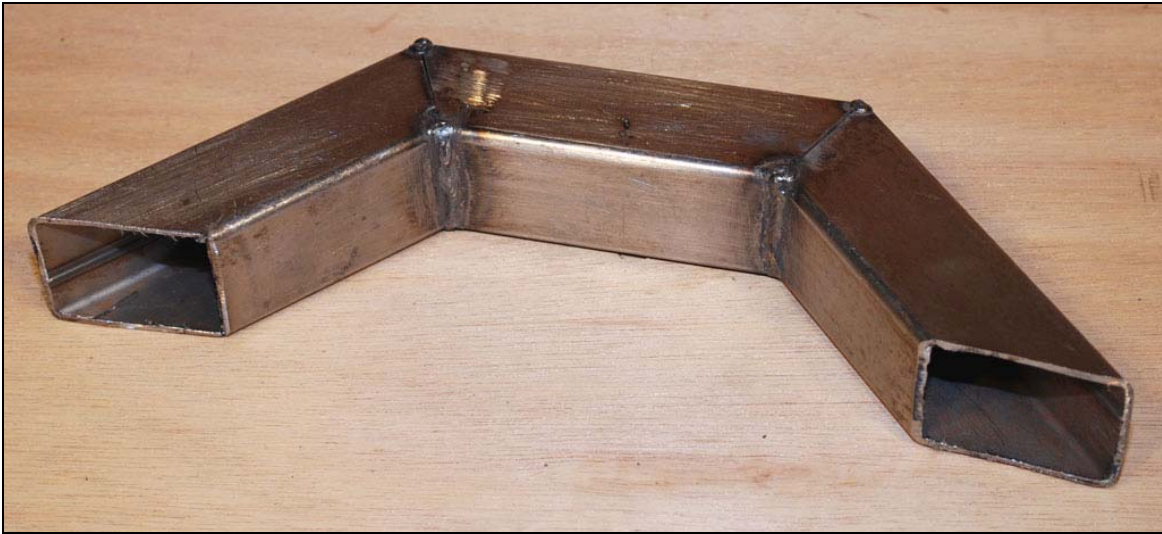


Figure 42 – Following the usual order of weld operations

The top and bottom joints are completed first, as usual to keep heat distortion to a minimum. Figure 42 shows the top and bottom welds completed.



Figure 43 – Both bearing supports are equal in height

After a little tandem grinding in the vice, both bearing supports are exactly the same height when stood together as shown in Figure 43. The top

welds have been ground flush so that the pillow block bearings have a flat surface on which to sit. If the base of the bearing supports have a large gap, weld them all down together to make welding easier. Remember, the goal is to make both of them 3.5 inches in height, and as equal as possible.



Figure 44 – Installing the bearing supports

The bearing supports are installed onto the underside of the rear frame box as shown in Figure 44. It may seem odd that they are not positioned in the center of the square to disperse the weight more evenly, but because of the overall length of the trike, this was not necessary, and it keeps the wheelbase a little shorter. I have placed 250 pounds on my flatbed, and it did not lift the front wheel off the ground, so unless you plan on really loading up your trike, this bearing placement is probably best.

The goal of building your own vehicle is to create something that suits your needs, so feel free to make any modifications you like as long as you understand how they might affect the final design. There is no reason why you couldn't make the rear frame 6 feet squared, and place the wheels in the center to carry a thousand pounds! Of course, a vehicle of that capacity might not be safe on the street, and would need some serious brakes.



Figure 45 – Welding the bearing supports to the rear frame

As usual, the front welds are completed first before moving on to the sides of the joint as shown in Figure 45. The inside joints do not need to be done, as they do not add any extra strength, and would be hard to reach.

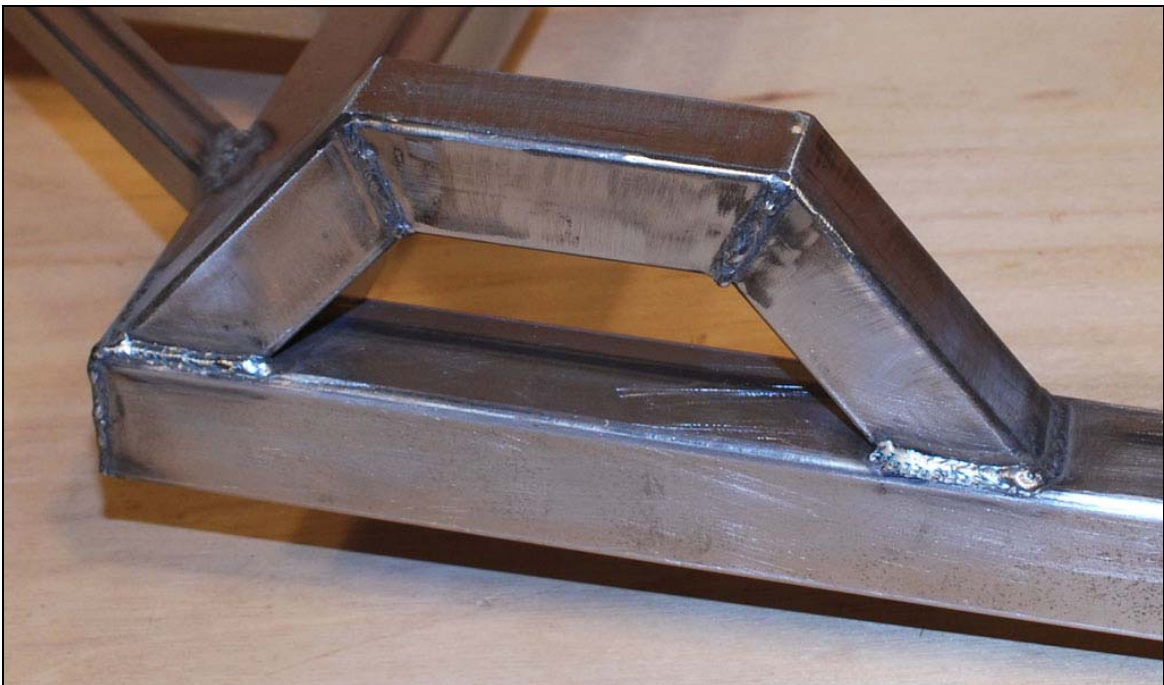


Figure 46 – Bearing supports completely welded

The sides of the joint are welded to the rear frame box as shown in Figure 46, completing the installation of the bearing supports. If you flip the frame over and stand it on the bearing supports, the rear frame should be perfectly level.

Installing Pillow Block Bearings and Axle



Figure 47 – You will need four pillow block bearings

You will need four identical pillow block bearings that will fit a $\frac{3}{4}$ inch shaft like the one shown in Figure 47. These bearings might seem a bit heavy duty, but the goal is to create a maintenance free and durable trike, so they are perfectly suited for this task. Most pillow block bearings include a hollow space under the bolt holes in the cast iron housing as shown in Figure 47, and this is important since the bolt that hold them down have a bit of weld metal around them. Read ahead a bit and you will see why this space under the bolt holes is important. In a pinch, you could probably grind a space out using a small grinder disc, but I would avoid doing this.

Oh, and that grease nipple can be removed and thrown away, as it does not lubricate the bearing, as many might think. That grease nipple will only fill the space between the bearing race and the cast iron shell with grease, and is only needed if you want to move the bearing around on the body a lot. The bearings are sealed for life and will never need grease.

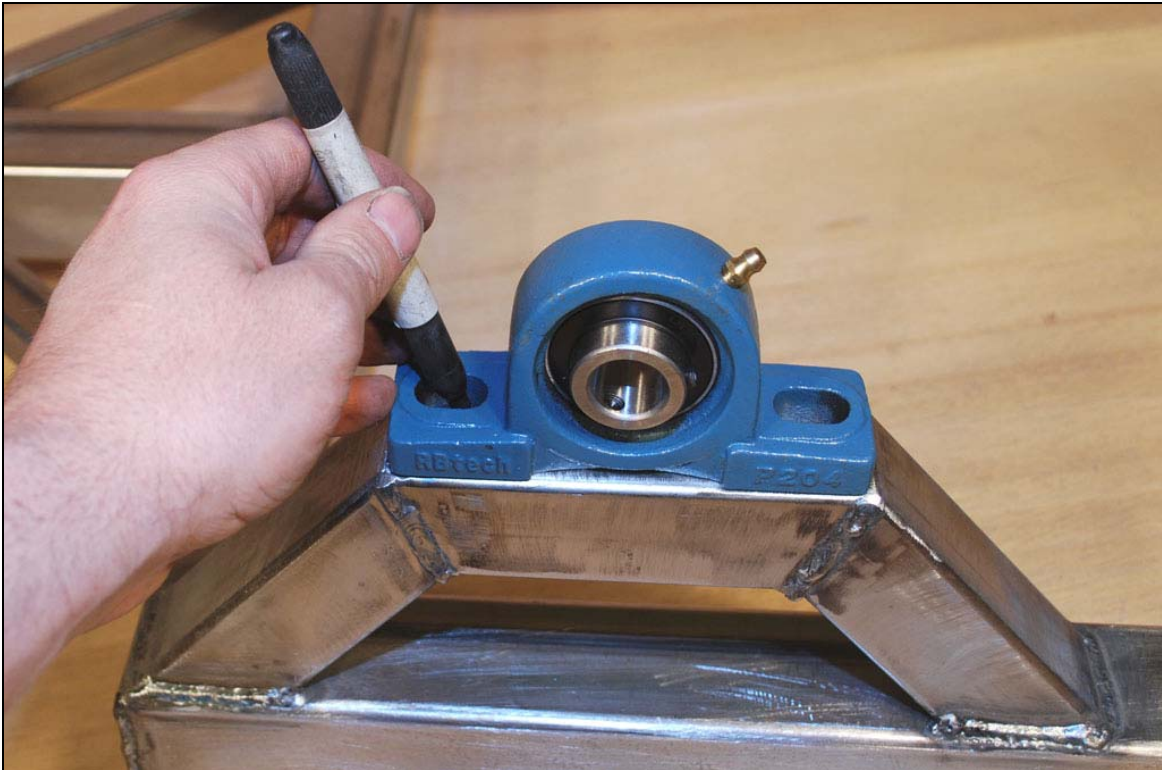


Figure 48 – Marking the bearing mounting holes

The pillow block bearings sit on top of the bearing support tubes as shown in Figure 48. Since the tube is the same length as the bearing body, drop them in place and mark the bolt mounting holes using a marker, as this is much easier and just as accurate as measuring them. Most of the bearing bodies have slightly slotted holes, so there is a bit of room for adjustment if necessary.



Figure 49 – Ready for bolt mounting

Drilling through the bearing mounting tubes to install bolts is a bit unnecessary and might crush the thin tubing walls, so the bolts will be welded directly to the tubing instead. This method allows you to tighten the bolts more than if they were placed through the tubing because the tubing would tend to crush inwards from the force of the bolts. Is this method strong enough, you ask? Well, after multiple tests on various vehicles I can assure you that it is. If you attempted to bash the bolt segment off the tube after it was welded, the tubing would bend before the bolt would break off, and unless you plan on riding in the demolition derby, your trike will never see forces like that.

Figure 49 shows the marked bearing holes, ready for bolts to be welded.



Figure 50 – Cutting up the threaded rod

You can cut the heads off of eight bolts, or simply cut eight lengths of 2 inch threaded rod to get the eight bolt segments. Choose a bolt size that fits the pillow block bearing perfectly with as little play as possible. As shown in Figure 50, you will also need eight washers and eight matching nuts.



Figure 51 – Bolt segments ready to weld

The bolt segments need to have enough length to allow the nut and washer to fit as shown in Figure 51. You could probably just cut all of the segments to 2 inches, as that would be plenty of bolt length.

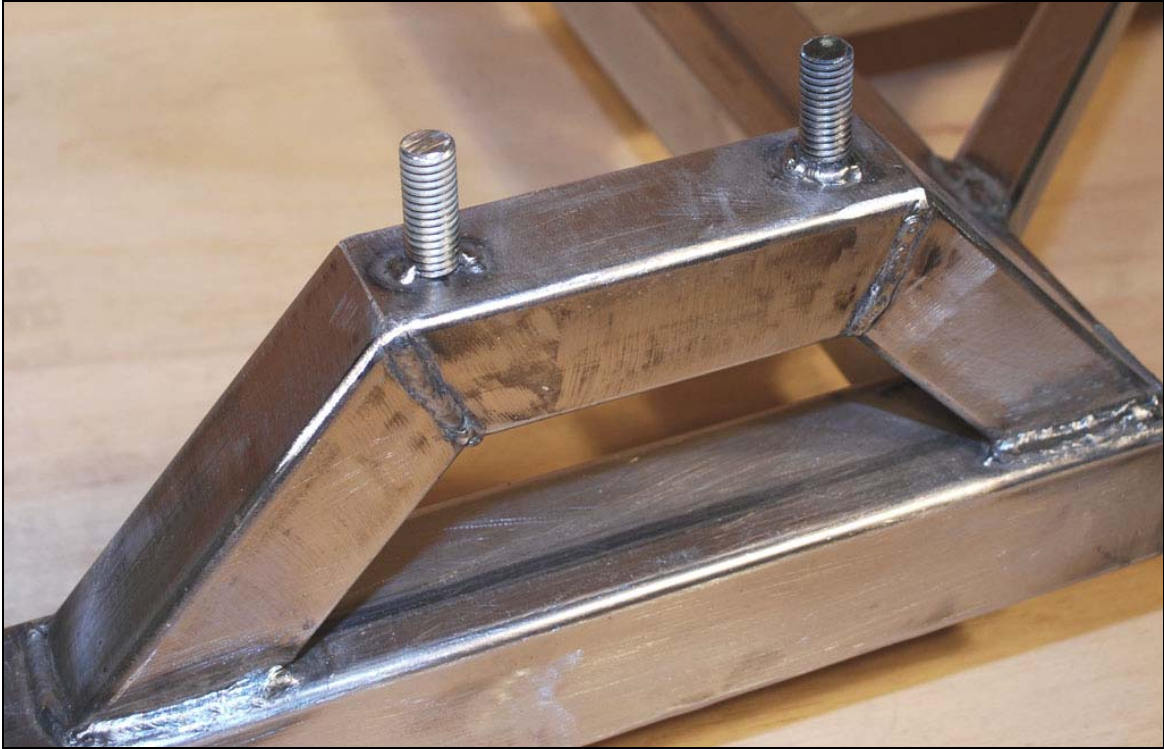


Figure 52 – Welding the bolts to the bearing supports

The bolt segments are welded to the bearing support tubes as shown in Figure 52, trying to keep them as vertical as possible. With a solid tack weld in place, you can easily tap the bolts around to straighten them before committing the rest of the weld. Welding around a bolt is great practice, and once you improve your “welding guru” skills, you can finish the entire joint without stopping.

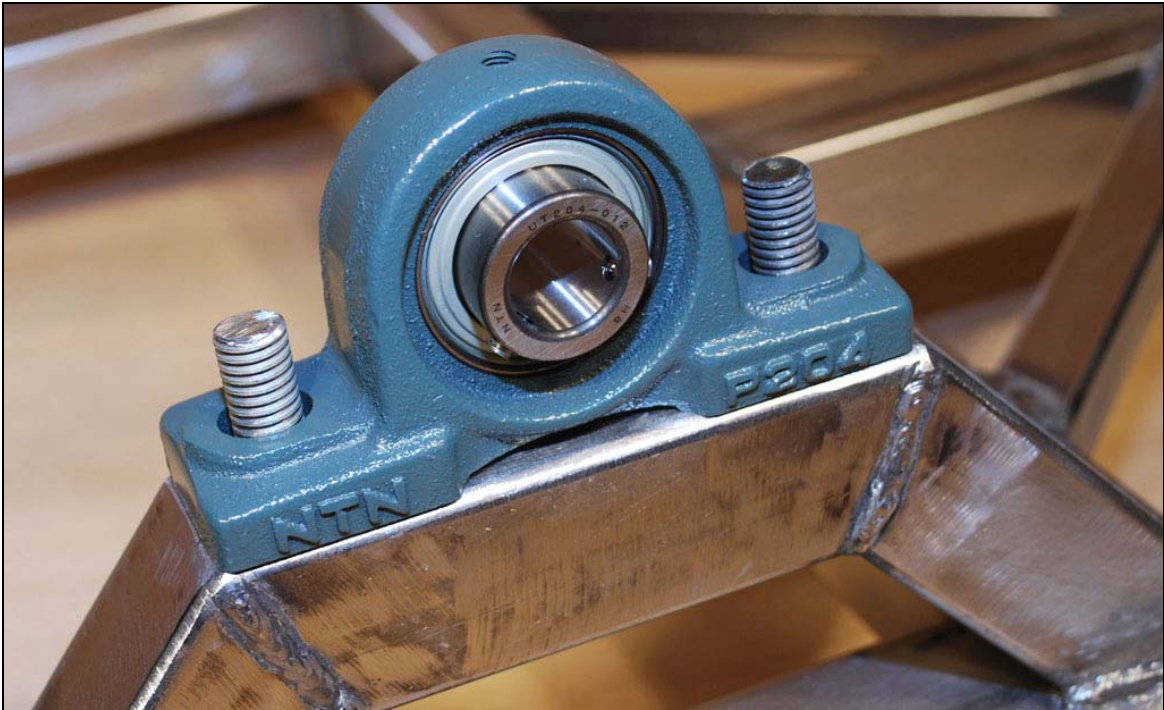


Figure 53 – Test fitting the bearings

Once the bolt segments are fully welded, see if the pillow block bearings will sit flat on the bearing support tubes. Chances are you will need to clean up the bolt welds a bit so they will sit perfectly flat as shown in Figure 53. Only take as much weld metal away from the bolt joint as needed, or you could weaken the joint. If you are a skilled welder, then the penetration of your welded joint will be good enough that you could probably grind 90% of the weld metal away without weakening the joint.

When you have all four bolt segments welded and the bearings sitting flat, tighten up the bolts. If your bearings have a long and short ring face (usually to hold the set screws), then face the long side outwards as shown in Figure 53.

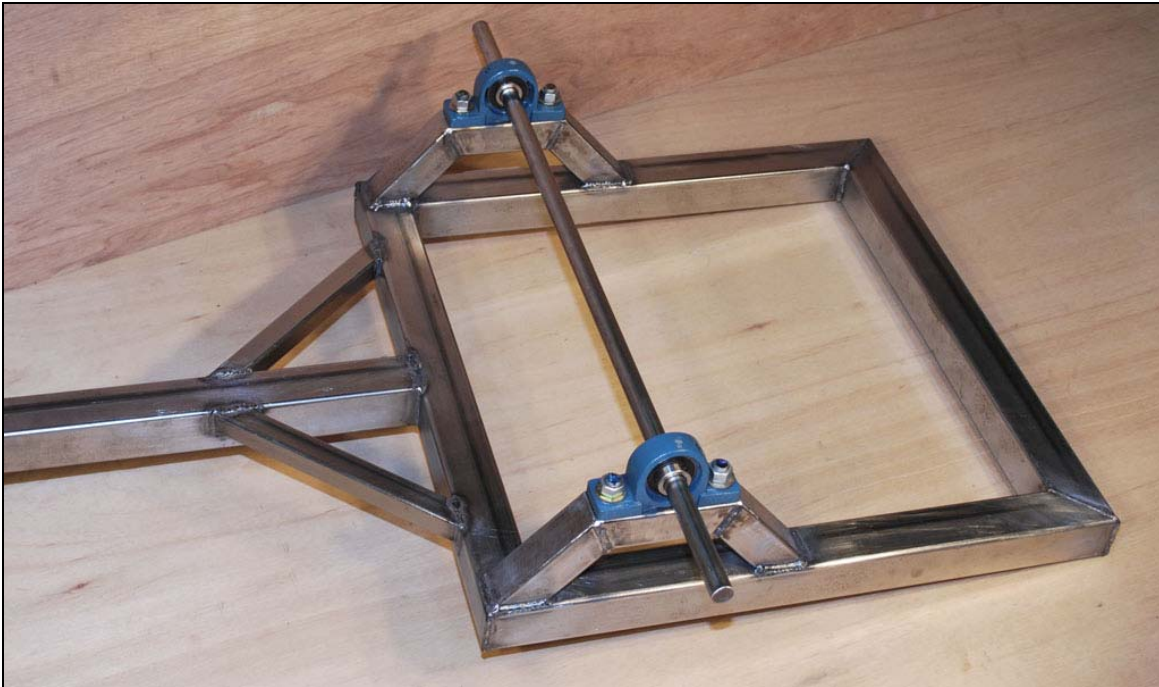


Figure 54 – Perfectly aligned single axle

You will now need a 34 inch long piece of cold rolled $\frac{3}{4}$ inch diameter steel to make your two rear axles. When purchasing the axle material, ensure you are getting cold rolled, not hot rolled steel or the axle will be out of round and impossible to slide into the bearings. You can also use superior ground rod, but it may cost a little more and is not really necessary. Just tell your supplier that the axle better slide into your bearings or you will be back.

The reason I chose to work with a single axle at first is to aid in the alignment of the two inner bearings. With the two outer bearing holding the axle in place as shown in Figure 54, it is very easy to find the perfect place for the two inner bearings. Doing this any other way would be extremely difficult and likely result in two badly misaligned rear wheels. Misaligned rear wheels will scrub, resulting in a massive power drain and fast tire wear.

How about just using the single axle the way it is rather than having two axles and four bearings? If you did that, you would create a trike that would not go around corners. Since the rear wheels turn at different speeds as you corner, the solid axle would try to make one wheel skid around the corners, and since so much of the weight is at the rear, this would likely cause the front wheel to skid along in a straight line no matter how far your turned it. If you did manage to get the trike to turn a corner with a solid axle, the effort that this would take would either destroy the rear wheels or tire you out in seconds! To drive both rear wheels, you would need a geared differential - a complex setup that splits

the difference between both wheels. This is unnecessary and would increase weight and complexity to ridiculous proportions.

Also, file or lightly grind the ends of all cut axles to remove burs and high spots or it will be very difficult to slide the axle into the bearings. Never hit the ends of the axle with a hammer or steel object, and try to keep the axle lightly oiled. These tips will save you some frustration later on.



Figure 55 – Inner bearing mounting plate

Now that you understand why all three and four wheeled vehicles need independent rear axles, let's get the two inner bearings installed. The plate shown in Figure 55 is at least 1/8 inch thick, and is cut large enough so that both pillow block bearings can sit on top. Just like the bearing mounting tubes, four bolt segments will be welded in place to hold the bearings to the plate.

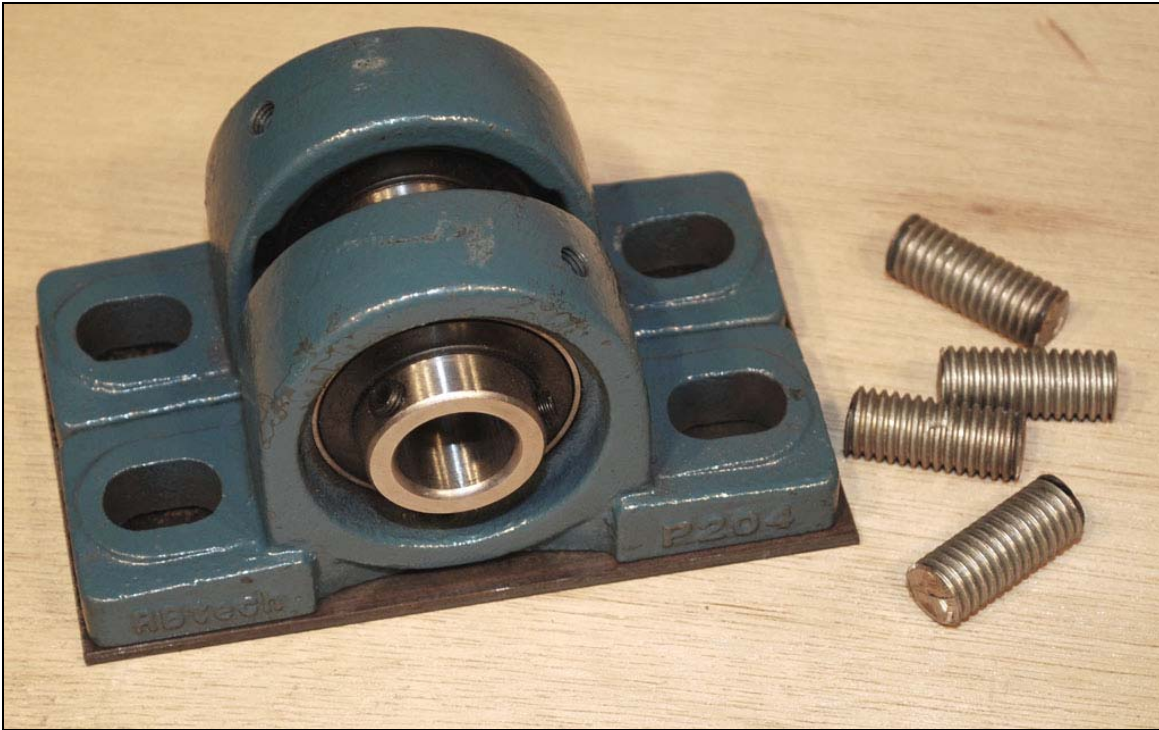


Figure 56 – The plate is the same size as two bearings

The plate only needs to be as large as the two bearing bodies as shown in Figure 56. Also shown are four more bolt segments ready to be welded to the plate to hold the bearings in place.



Figure 57 – Inner bearing assembly complete

The inner bearing assembly is shown complete in Figure 57. If your bearings have a long and short ring face (usually to hold the set screws), then face the long side outwards as shown in Figure 57.



Figure 58 – The center bearing support tube

Rather than messing around with fractional angles that would need to be within 1/16 of an inch tolerance, I will show you how to get the two inner bearings perfectly inline without ever touching a protractor. The tube shown in Figure 58 is an 8 inch long piece of the 2 inch frame tubing with a 45 degree cut made at one end. This tube will joint the inner bearing support plate to the frame, and will be cut to the correct size by using the solid axle as a guide.

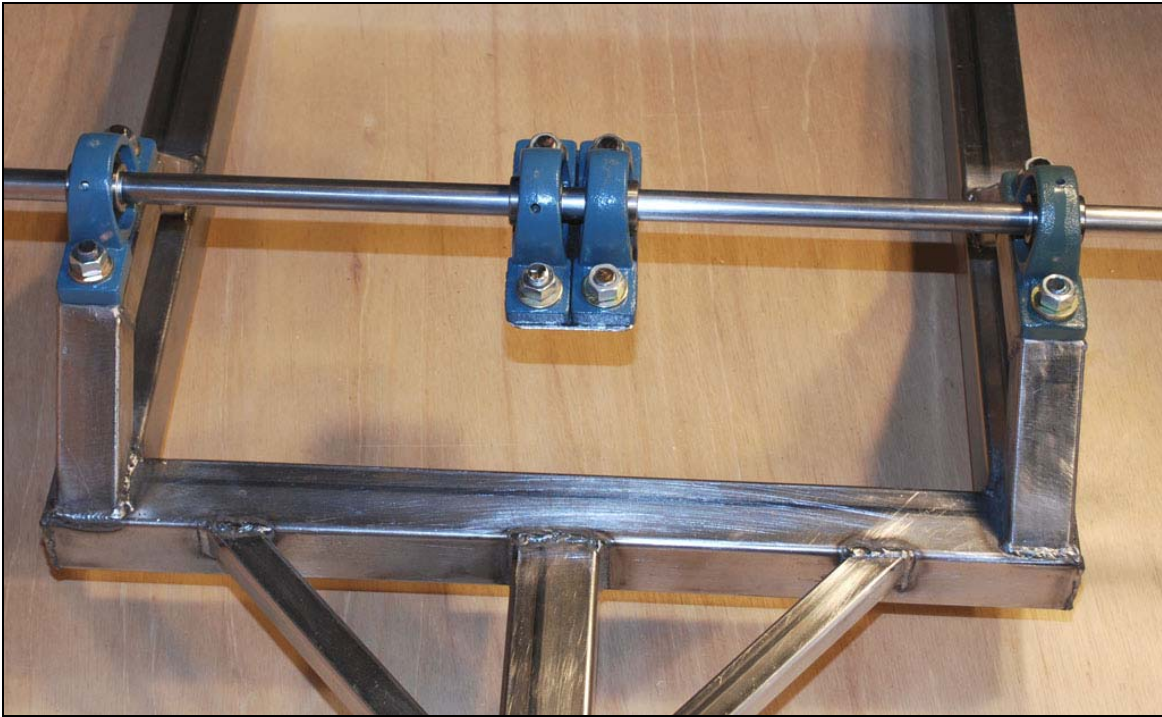


Figure 59 – Install the two center bearings

The center bearing assembly is placed on the axle as shown in Figure 59. You may need to play around with the bearing races to get them to align while you slide the axle through them. Don't worry, once they straighten, it won't be as difficult to get them installed next time.



Figure 60 – Letting the bearings center themselves

Figure 60 shows the secret method used to get the center bearing assembly in perfect alignment with the out bearings. By simply placing the 45 degree tube on the frame, you can then rotate the bearing assembly, mark a line on the end of the tube and then cut it to the perfect length. It will look as though you had NASA design the completed frame, but in reality, the bearings simply line themselves up without even worrying about exact angles and lengths. Figure 60 shows a marker line made by tracing the edge of the center bearing assembly along the face of the tube.



Figure 61 – Marking the bearing plate tube for welding

Use a square to transfer the line you made from Figure 60 around the center support tube and then cut it all the way around. Once cut, it should fit into place as shown in Figure 61, allowing you to trace around the tube to while it is placed in the center of the bearing support plate.



Figure 62 – Tack weld the tube to the plate

With the line drawn in the last step as a guide, tack weld the tube to the underside of the bearing assembly as shown in Figure 62. After a few tack welds have been made, place the assembly back on the axle, and ensure that the 45 degree cut end of the tube drops flat on the frame. If everything checks out, then remove the assembly for final welding.



Figure 63 – Welding the tube to the bearing assembly

The support tube is welded to the bearing support plate as shown in Figure 63 once it has been checked for a proper fit. Once welded, place the bearings and assembly back on the axle.

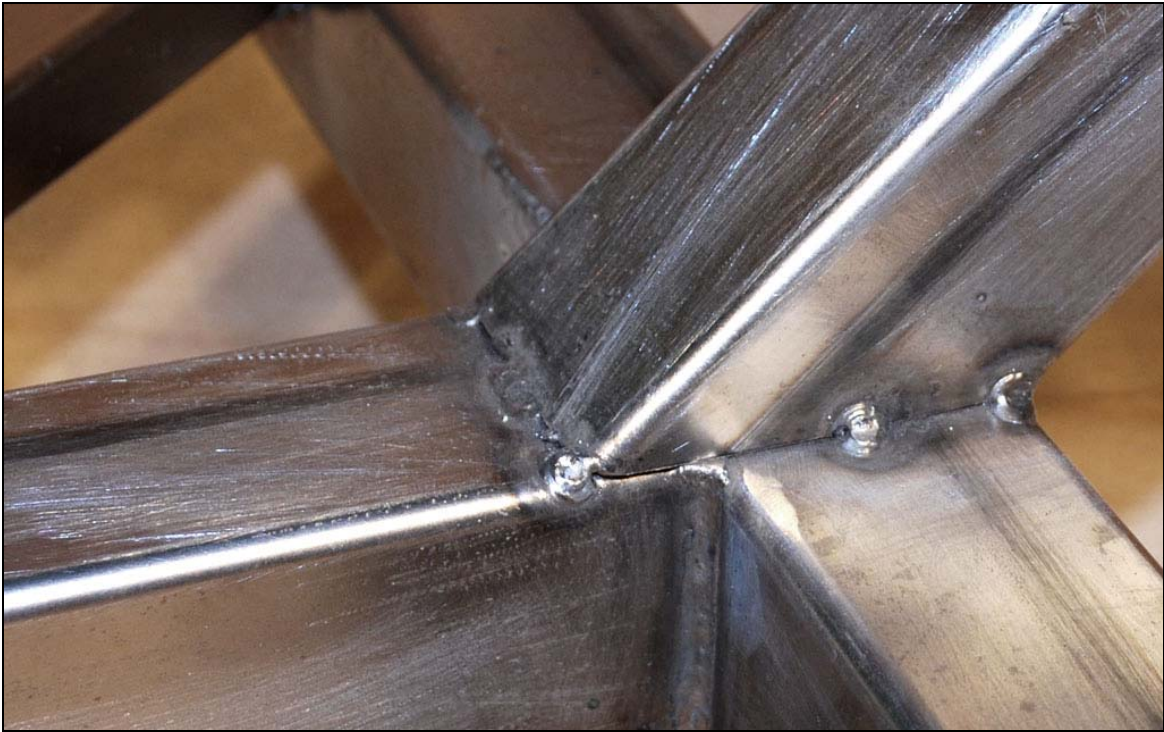


Figure 64 – Welding the support tube to the frame

The center bearing support tube will finally be welded to the frame wherever it lands as shown in Figure 64. Since the bearings are lining themselves up, you don't have to be concerned with exact angles, just let the 45 degree end of the support tube fall onto the frame, and then make a few corner tack welds to hold it in place.



Figure 65 – Weld the front of the joint first

Order of welding operations is very important when welding the center bearing support tube to the frame. Start with the front of the joint as shown in Figure 65, as this joint will not tend to pull the tubing out of its perfect natural alignment. This is done with the axle installed, and the welding ground clamp on the frame, never on the axle. If you placed your ground clamp on the axle and tried to weld the frame, the bearings would be badly damaged from the current that would flow through them.



Figure 66 – Finish the side joints last

After the front and back side of the bearing support tube have been welded to the frame, complete the side of the joints as shown in Figure 66. Keep the side joints to a minimum, and run the bead fast. It may be a good idea to weld a bit at a time and then switch sides, as any amount of side-to-side distortion will affect the axle alignment, especially once the axle is split in two.

No matter how much of a welding Jedi you are, there will be enough distortion on this tube to make it difficult to slide out the axle once the tubing has cooled. Don't be alarmed if you actually have to hammer out the axle with a 2 x 4, as even a tiny amount of deflection will cause the bearings to grip the axle with great force. This is not a problem and is to be expected. The problem will be cured once the axle is cut in half, and if you simply loosen the four inner bearing bolts, the grip will be eliminated. Remember not to pound out the axles with a hammer unless it is rubber, or by using a block of wood over the end.

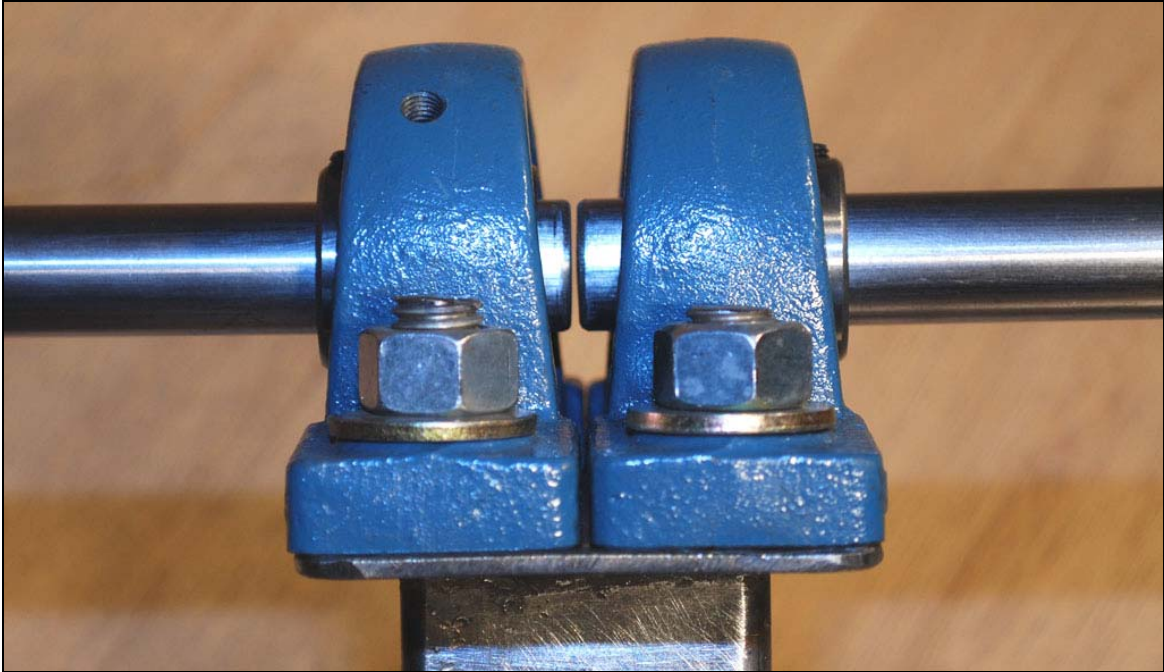


Figure 67 – Cutting the axle in half

Once you remove the axle from the bearings, find its center and cut in it half and then file or bevel the edges with your flap disc. You now have a dual axle system that is very well aligned. Figure 67 shows the two axles after cutting and reinstalling them. Now, let's move on to the part that you have either been dreading or dying to try – the wheel building process.

Building the Wheels



Figure 68 – You will need a pair of BMX wheels

One of the most unique features of the LodeRunner is that it has no rear hubs. The flanges that hold the spokes are actually part of the rear axles, so this greatly simplifies the design and saves the builder a lot of money that would otherwise go to purchasing expensive aluminum hubs to be machined. Retrofitting a standard hub over an axle is not only wasteful, but it adds that ugly bolt on the outside of the wheel, making it look hacked together. By integrating the wheels right onto the axle, you create a great looking assembly that can take advantage of the inexpensive and super strong 48 hole BMX rim.

To create the rear wheel and axle assemblies, you will need a pair of identical BMX front wheels like the ones shown in Figure 68. Because a ready made wheel is a lot less expensive than sourcing a rim and the proper length

spokes, this is the best way to go. These wheels are super strong, lightweight, and easy to find at any cycle shop as they are used on all those freestyle BMX bikes. Just ask for a pair of 48 hole 20 inch front wheels for a BMX. I purchased three wheels, and used the third one for the front so they rims would all match.

If you have never thought about spoking up a rim - don't worry, it is not very difficult! Because you know that the spokes will be the correct length, the wheel building is nothing more than a simple job of replacing the spokes they way they were on the original wheel. There are many good wheel building guides on the Internet, but before we get that far, the first thing you need to do is remove all the spokes from the pair of wheels as shown in Figure 68.

Start at the valve hole and turn each spoke head counterclockwise half a turn each. Keep doing this as you go around the rim until the spokes all feel fairly loose. This procedure will ensure that the rim does not warp as you remove the spokes. You also get to learn patience this way – the one trait that makes a true wheel builder!

Hub Flanges

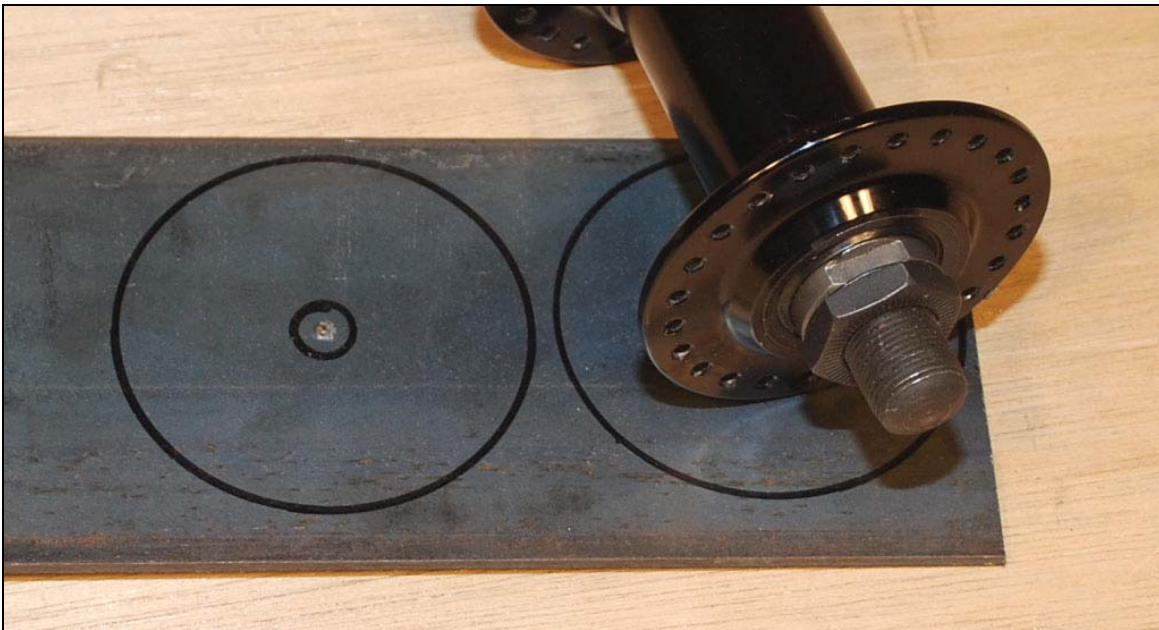


Figure 69 – Copying the hub flanges

The hub flanges are nothing more than steel discs made from 1/8 inch thick steel plate or flat bar. The goal is to copy the hub flanges that came from

the wheels you took apart so you can rebuild them directly on the axles. There are 3 ways you can make the 4 needed hub flanges.

1) Take the original hub to a machine shop and tell them you want four steel discs that are 1/8 inch thick and exactly the same diameter as the original hub flange. The discs also need to have a $\frac{3}{4}$ hole in the center so they can fit over your axle. If your machine shop has decent rates, you could also get them to make the spoke hole drillings, but were would the fun be in that!?

2) You can source out precision steel washers that come close to the needed dimensions and then drill out the spoke holes. This is certainly possible as shown by some of the ingenious AtomicZombie forum members. You may need to drill out the washer hole to fit the $\frac{3}{4}$ axle, and have to look for washers that are not much thicker than 1/8 inch or the spokes will not install properly.

3) The ultimate DIY method is to simply cut out your own flanges using a hole saw or by hacking them out some flat bar using only your angle grinder. Being a hardcore minimalist, I chose the last method.

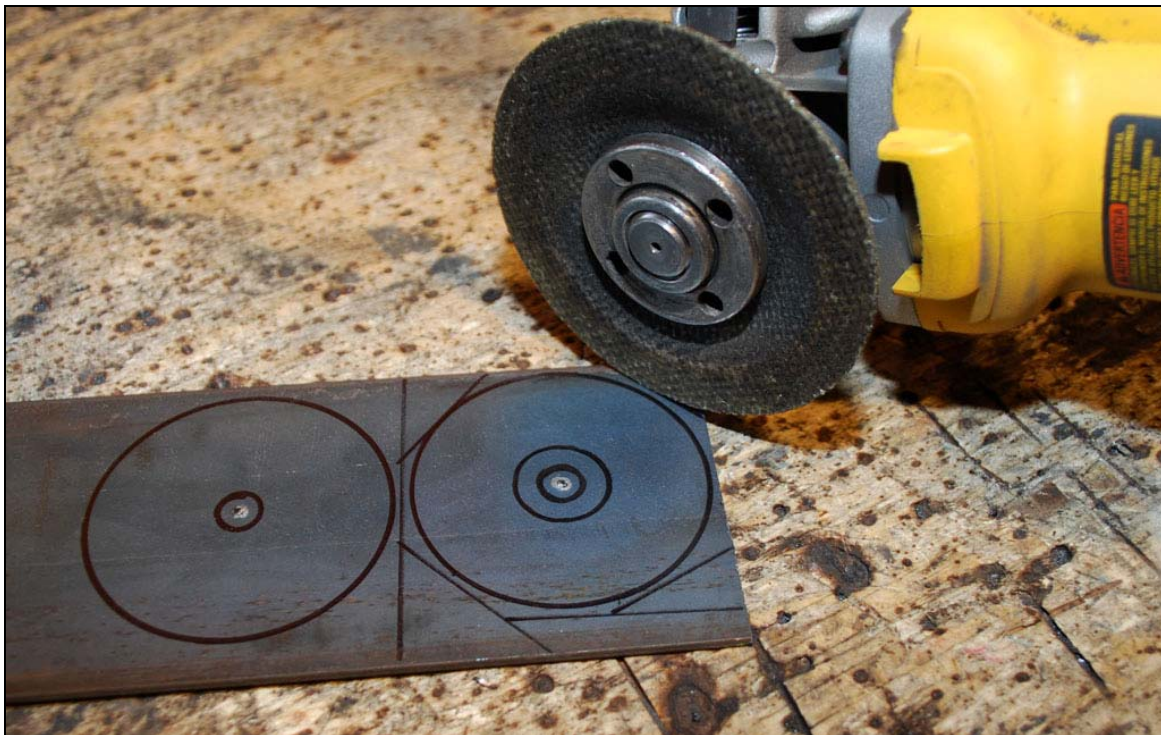


Figure 70 – Hacking out some hub flanges

Before you start either of the hub flange making options, you need to know the exact diameter of the hub flanges on the wheels you pulled apart. My flanges were 2.25 inches in diameter, so I traced four circles onto some 1/8 inch

flatbar as shown in Figure 69 and 70. Use a punch to mark the hole center, as it will be impossible to find later. Also shown in Figure 70 is my minimalist approach to cutting out the discs – using a zip disc and angle grinder. A quality metal cutting hole saw would also work perfectly for this.



Figure 71 – Cleaning up the edges

Once I hacked out the four discs from the flat bar, I cleaned up the edges using a heavy grinder disc as shown in Figure 71. I don't own a bench grinder, but if you have one, it will do this job perfectly.



Figure 72 – The disc on the right is perfectly round

Like a painter's brush, the angle grinder is the tool of the trade when it comes to the art of bicycle building. It took only minutes to get the disc shown on the right of Figure 72 perfectly round. The remaining discs were then ground round by following the marked line.



Figure 73 – Four perfect 2.25 inch discs

Once all four discs were perfectly round, the centers were drilled using a 1/8 inch drill bit. It is important to start with a small bit and work your way up in order to keep the hole from wandering. As mentioned by forum members, a step drill will do the same task as using multiple drill bits, so it is much faster. Using the minimalist approach, I used multiple drill bits and a hand drill. Figure 73 shows the 4 drilled discs, ready for the larger bits.



Figure 74 – Drilling all discs at once

To drill all four discs as accurately as possible, it is easier to place them all in the vice as shown in Figure 74. If you have a drill press, then this is not so much of an issue since the drill bit will always hit the work in a perfect vertical position. A drill press is another tool I have not found the need for yet.



Figure 75 – Half inch is as far as I could go

Using only a hand drill, you are limited to the size of bits that you can use. My drill chuck could handle a drill bit of $\frac{1}{2}$ inch, so that is where I had to stop as shown in Figure 75. To get to this size hole, I used six bits of varying sizes up from the original $\frac{1}{8}$ bit. Stepping up one size at a time make a much more accurate hole, which is what a step drill bit will do for you.

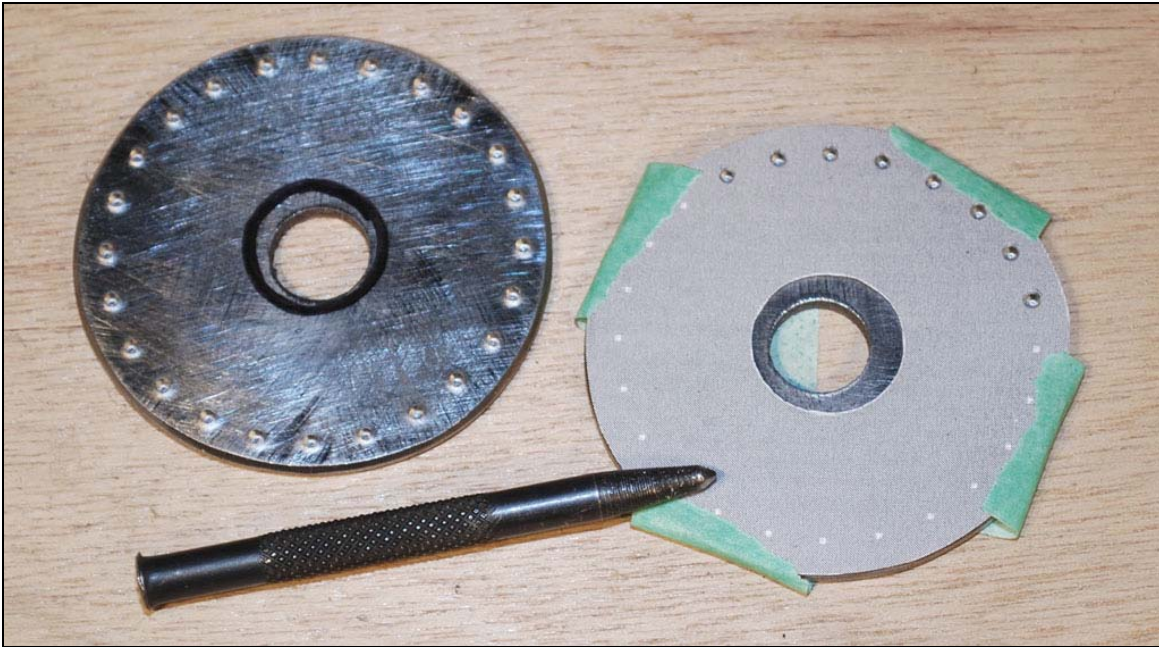


Figure 76 – A spoke and axle hole template

Because my hand drill could only handle a $\frac{1}{2}$ inch bit, I had to complete the $\frac{3}{4}$ inch holes using a round file. This was not a real problem since the accuracy of the hole was not perfect due to the hand drill as shown in Figure 76. I made a paper template using a simple computer CAD program and then printed it to aid in the punching and drilling of the spoke holes (24 per disc). Notice how far the $\frac{1}{2}$ inch hole has wandered when compared to the template.

To make a paper template, you can use a compass or simple CAD program to divide a circle into 15 degree segments (360 degrees / 24 holes). The donut shaped template was then cut out and taped to the disc as a punching guide. Supplying a template would be difficult as my flange size may differ from yours, and there is no way to ensure that your printer would print the same diameter template that mine did. If you do not have the software or tools to make a template, ask a computer savvy pal to make them for you in exchange for a ride in your new trike.

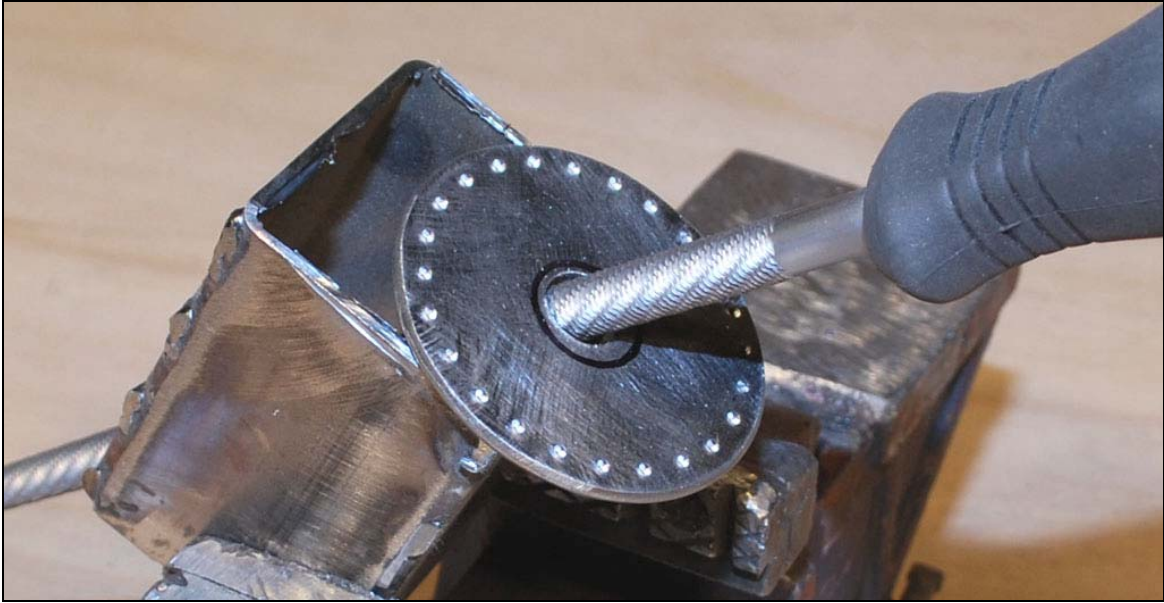


Figure 77 – Fixing the hole position

To make the $\frac{3}{4}$ inch hole and repair the errors from hand drilling, a round file is used to complete the hole. As shown in Figure 77, the job is made easy by placing the disc over some tubing so you can really work the file vigorously around the hole. It took about 15 minutes of filing per disc to get the holes perfectly centered and to the correct diameter.

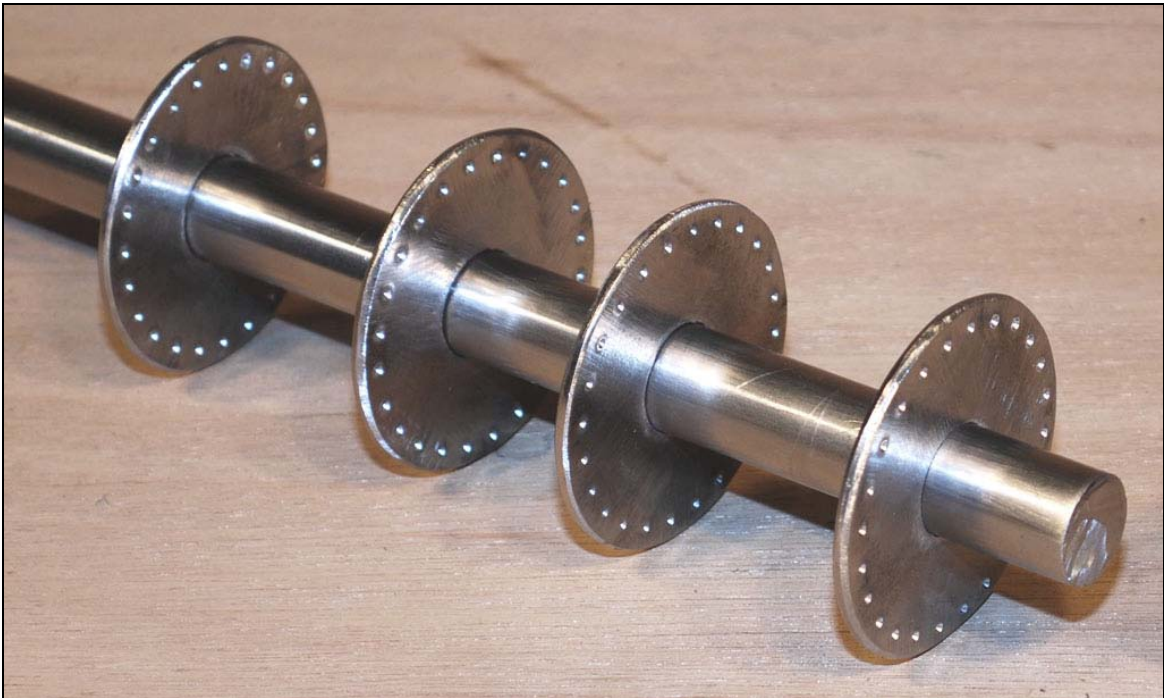


Figure 78 – Flanges ready for spoke hole drilling

The four hub flanges are shown in Figure 78 after cleaning up the holes using a little elbow grease. The discs are very accurate considering they were made with minimal tools and effort. These four discs actually fit on the axle a lot tighter than the last 4 that I had done at the machine shop!



Figure 79 – Drilling 96 holes is a little boring

The flanges now have to have 24 holes drilled in each one, making a grand total of 96 holes to drill. You will need a few decent 3/32 inch drill bits and about two hours to waste in your garage for this job. If the force is with you, then you might be able to drill all 96 holes without snapping a single bit, but that is unlikely, so purchase a few before you start. It also helps to drill horizontally as shown in Figure 79 for those of you who do not own a drill press (myself included). Just bolt the flanges to the edge of your workbench and “go to town” with the hand drill.



Figure 80 – Beveling the spoke holes

The spoke holes need to be beveled after the initial drilling, or the spoke will have a difficult time making it around the bend. The holes are also very sharp, so the beveling process takes off the sharp edges of the hole. As shown in Figure 80, beveling the holes is as simple as pushing them lightly against a spinning 3/16 inch drill bit just to take off the sharp edges. This process is done on both side of the disc, and takes only a few minutes.



Figure 81 – Beveled hole shown on the left

As you can see in Figure 81, the beveled hole on the left of the photo are much friendlier to the spoke than the freshly drilled holes on the right. If you have a close look at our original hub flange, you will notice that it also has beveled holes. Even the cheapest bicycle hubs have beveled holes.

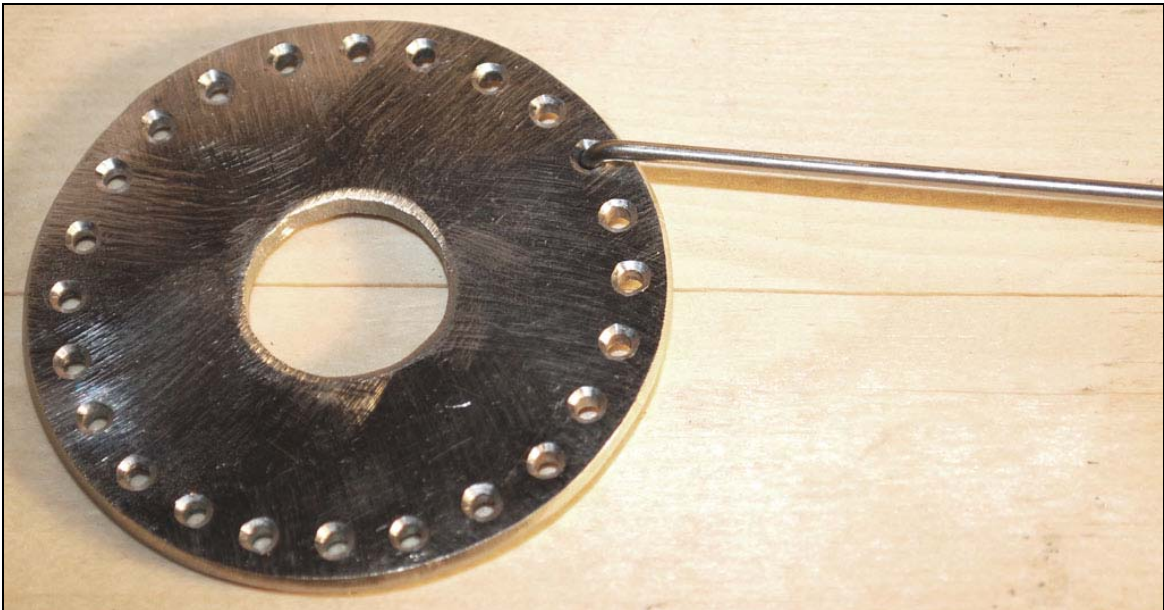


Figure 82 – Testing a spoke in the hole

The spoke should slide into the hole and easily around the bend once the beveling process is completed. As shown in Figure 82, the spoke fits snugly around the hole, just like it did on the original hub.



Figure 83 – Hub flanges from thin air!

It feels good to create something from virtually nothing! As shown in Figure 83, the four hub flanges are almost as good as machined parts, and cost only my time to make – time that I enjoy spending at a great hobby. If you put your best effort into your work, it will really show in the final product.

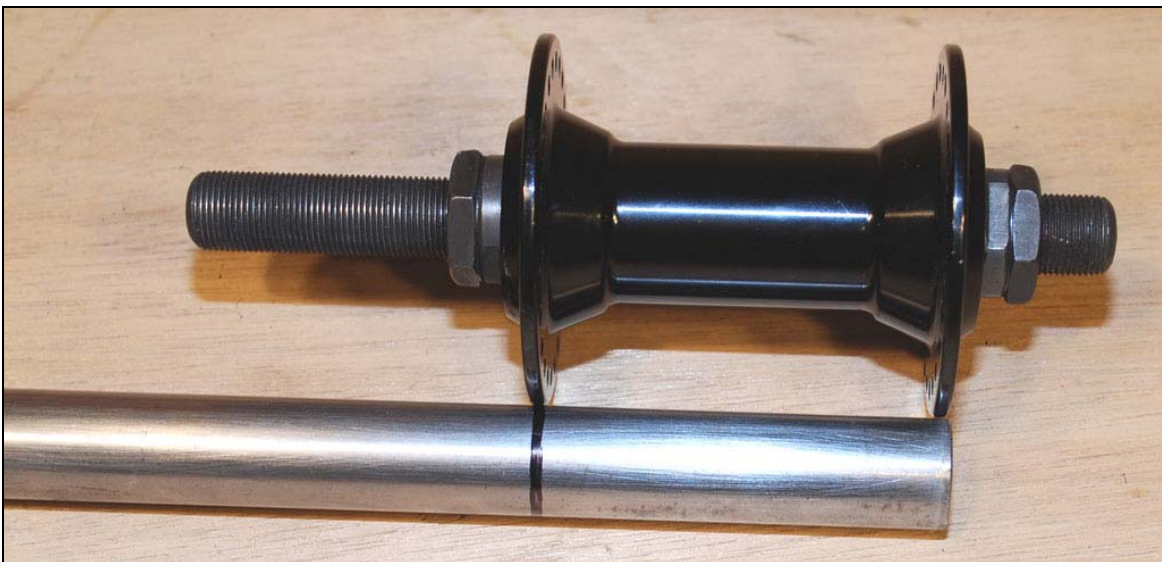


Figure 84 – Marking the hub flange width

The hub flanges will be welded directly to the rear axles, creating a clean looking and incredibly strong rear wheel assembly. Again, you will be following the original design of the hub you are copying, so place it up against

the end of the axle and mark the flange width as shown in Figure 84. By keeping the flange width and diameter the same, you are certain that the spokes will fit the rim perfectly.



Figure 85 – Tack welding the inside flange

The inside flange will be the first one to be tack welded to the axle, as shown in Figure 85, the welder's ground clamp should be placed directly on the axle, not the frame if you are doing this with the axles installed in the bearings. You should never place your welding ground clamp in any place that would cause the current to flow through the bearing into the weld area.

If you clamped to the frame, the current would need to travel through the inner and outer bearing races and through the actual ball bearings to complete the circuit, which will damage the bearings. Since each ball bearing only contacts the inner and outer races by a very small surface area, the high welding current will create a pit in the bearing races, causing what would seem like years of wear on the bearing. If you are welding in a vice, then this is not a concern.

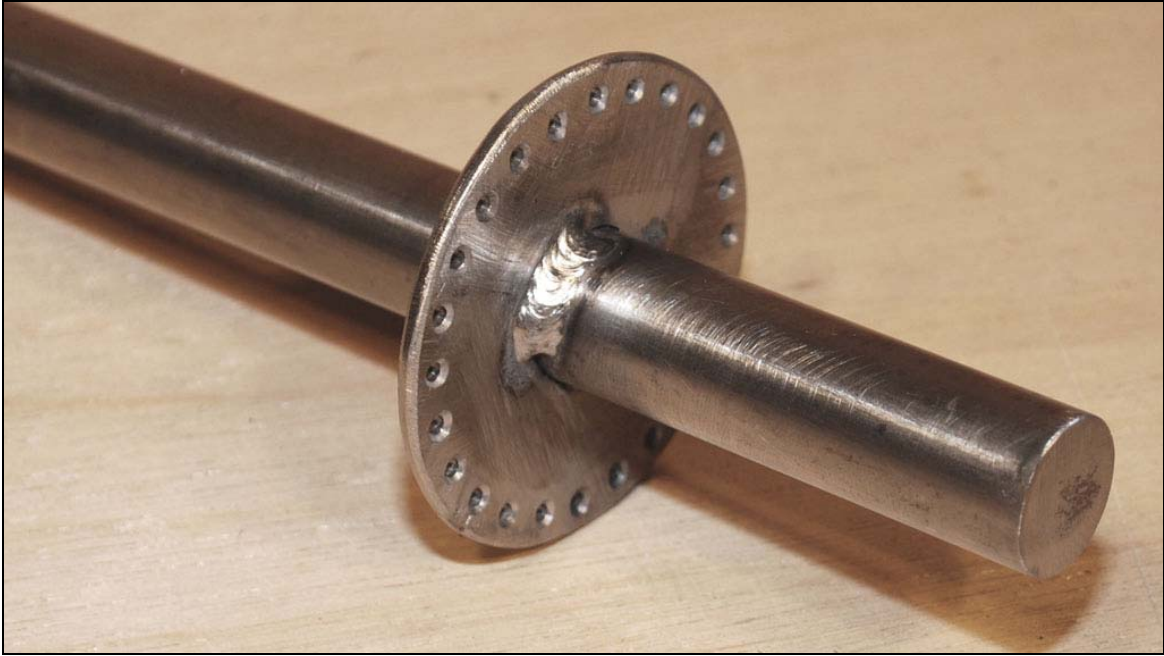


Figure 86 – A larger weld on the other side

Once the tack weld has cooled, remove the ground clamp and spin the axle to check alignment. It is very easy to see any misalignment of the flange as you turn the axle, and this is corrected using a few small taps of a hammer along the disc until it spins true.

A very slight wobble is not a big deal in the end, since the spokes will correct this, but do try to get the disc spinning as true as you can while it is easy to manipulate. Once spinning true, make a larger weld across from the original tack weld as shown in Figure 86.



Figure 87 – Flange welding completed

The hub flange can now be welded around the entire joint as shown in Figure 87 now that the solid tack welds are securing the flange to the axle. If you get a helper to slowly turn the axle while you weld, it is possible to do the entire joint in a single pass. Once you are done welding the entire distance, place the axle back into the pillow block bearings and give it a spin to check alignment.

A very slight wobble is not a big deal, but if you think there is too much misalignment, a few whacks of the hammer may still cure this. Any misalignment less than the thickness of the actual disc will be acceptable and will have no effect on the wheel building process, nor will it show in the final build, so do not spend too much time and effort trying to get the disc spinning with "military accuracy".

Do not weld the other side of the joint on the inside flange. It is not necessary, and will only make it more difficult to center the axle and disc brake later.

Outer Flange

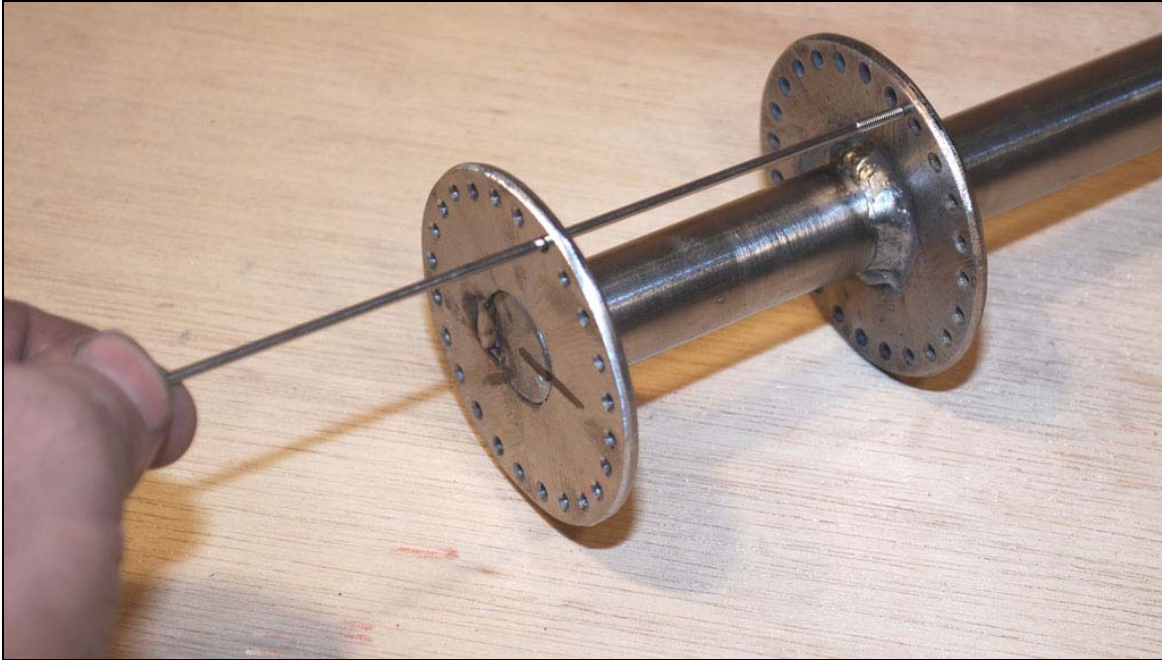


Figure 88 – Opposing spoke holes are offset

Before you start welding the outer flange, have a look at your original hub, and you will notice that the holes on each opposing flange are offset to each other. If you place a rod or spoke through one of the holes, it will not enter a hole on the opposing flange; it will hit the space between the holes. Every bicycle hub is manufactured like this, even the cheap steel units, and this is an important thing to do for wheel strength once the spokes are in place. Keep this point in mind when you start tack welding the outer flanges to the axle. A spoke or small welding rod can be used to check this like I am showing in Figure 88.

Use a marker to draw a line across the face as shown in Figure 88 after you set the hole offset. This line is then used as a guide when you make the initial tack weld. Do not do any more welding until you check the offset.

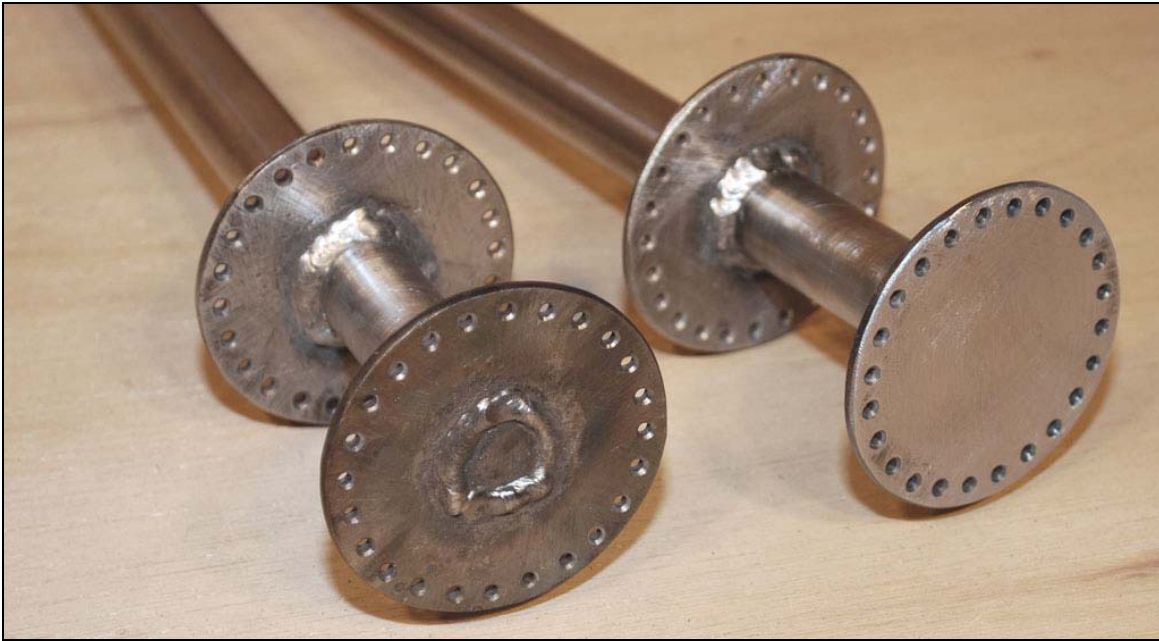


Figure 89 – Weld both sides and clean up the face

The outer flange is welded using the same method as the inner flange, spinning the axle to make sure the disc is true. Welding is done on both sides of the flange this time. Once the flanges completely welded, take your grinder and remove all weld material on the face of each hub until the disk is perfectly flat. Don't worry about the fact that most of the weld metal will be taken away, the inner flange welds and weld on the other side of this flange will hold the wheel on to the axle.

I like to start grinding with a heavy disc, and then once I'm almost to the face, I then place the axle back into the bearings and work it flush with a sander disc. You can have a helper turn the axle while you grind, or simply let it spin while you work to create a face that looks as though it were turned down in a lathe. Yes, you could also turn the face down in a lathe if you are lucky enough to have such tools. Figure 89 shows the results of cleaning up the face of the flange with a flap disc.

Painting Hub Axles



Figure 90 – Painting the hub axle units

The completed hub axle units need to be painted before you add the spokes, so do this now and then move ahead a few steps. You can come back to building the wheels after the paint has cured for a day or two. Figure 90 shows the completed hub axle units, which look much nicer than hubs that have been retrofitted to an axle. There is no ugly bolt or cotter pin hanging off the end of the hub, just nice a nice smooth face.

Truing and Spoking



Figure 91 – Using a guide to check the rim

Installing the spokes is an extremely simple task that requires no more than placing the spoke in the correct hole and giving the spoke nipple a few turns. It is the actual wheel truing operation that requires some skill or a bit of patience from those new to the art. I decided to install the spokes at this stage, and then continue building the rest of the LodeRunner. I decided to true the wheels once the paint was curing, since that takes a few days. The wooden handle shown in Figure 91 is actually being used as a guide to check the trueness of the rim as I work on the spokes. It takes about an hour to get each wheel spoked and running perfectly true.

There are many great wheel building tutorials on the Internet, and you still have the completed front wheel to use as a guide, so with a little reading and patience, you can do this job yourself. The 48 spoke 20 inch wheels are probably the easiest of all wheels to build, and will true up quite easily due to their stiffness.

Type into Google “Sheldon Brown wheel building”, and you will find a perfect wheel building guide written by one of the most knowledgeable cycle gurus of all time. Sheldon Brown (July 14, 1944 – February 3, 2008). Thanks,

Sheldon, for sharing your wealth of knowledge with the world.



Figure 92 – Wheels made for a trike

The completed rear wheels shown in Figure 92 are extremely strong and superior to any commercially available trike rear wheels that I know of. These 48 spoke BMX wheels are rated for a few hundred pounds each, so chances are your legs will fail to move the cargo before your wheels will give out! If you want to keep your rolling resistance down to a minimum, purchase high pressure tires with very minimal tread and inflate them to at 75-85 pounds. Aggressive tread tires should never be used on any bicycle that is not planning to traverse the deep woods or up the side of a mountain. Smooth, hard tires roll with much less friction.

Building Rear Axles



Figure 93 – Axle spacers made from handlebar tubing

At this point, the rear axles are not secured between the bearings since there is nothing stopping them from sliding out. Also, there needs to be some space between the wheel flanges and the frame, or the spokes will rub on the axle support tubing. To solve these problems, a few spacers will be installed on the axle so that you can push the axle right up against the outer bearing without having any part of the wheel hit the frame. Spacer material for the 3/4 axles can be made by cutting a 1/2 inch piece of mountain bike handlebar tubing as shown in Figure 93. You should have some handlebar tubing left over after you make the pilot's gooseneck extension, so this will work perfectly.

If your bearings are different than mine, then you may need something other than 1/2 inch for the spacer, so test fit the axle into the bearing until there is no less than 1/4 inch clearance between any part of the wheel and the frame.



Figure 94 – Outer axle spacer installed

Figure 94 shows the outer axle spacer made from the mountain bike handlebars fitting nicely over the axle. Install the same spacers for both rear axles.



Figure 95 – Cutting the axle to the correct length

The axles are probably longer than they need to be, so install them one at a time, and then use a marker to mark them where they stick out past the face of the inside bearing. As shown in Figure 95, a zip disc makes fast work of trimming the axles, which are then beveled slightly using a sanding disc.



Figure 96 – Clamping the inner axle lock

The bearings will likely include a set screw to lock onto the axle, but a trike that is designed to handle large loads will need more than that to lock the axle in place. Another 1 inch long section of handlebar tubing will do the job of an axle lock if placed in the other side of the bearing as shown in Figure 96.

This axle lock will need to have a hole drilled through itself and the axle to be fully secured, so clamp it down tight using a vice grip. Make sure the wheel is pushed up against the bearing as far as it will go and do the same with the small piece of tubing before you clamp it. There should be no side-to-side play in the axle at all.

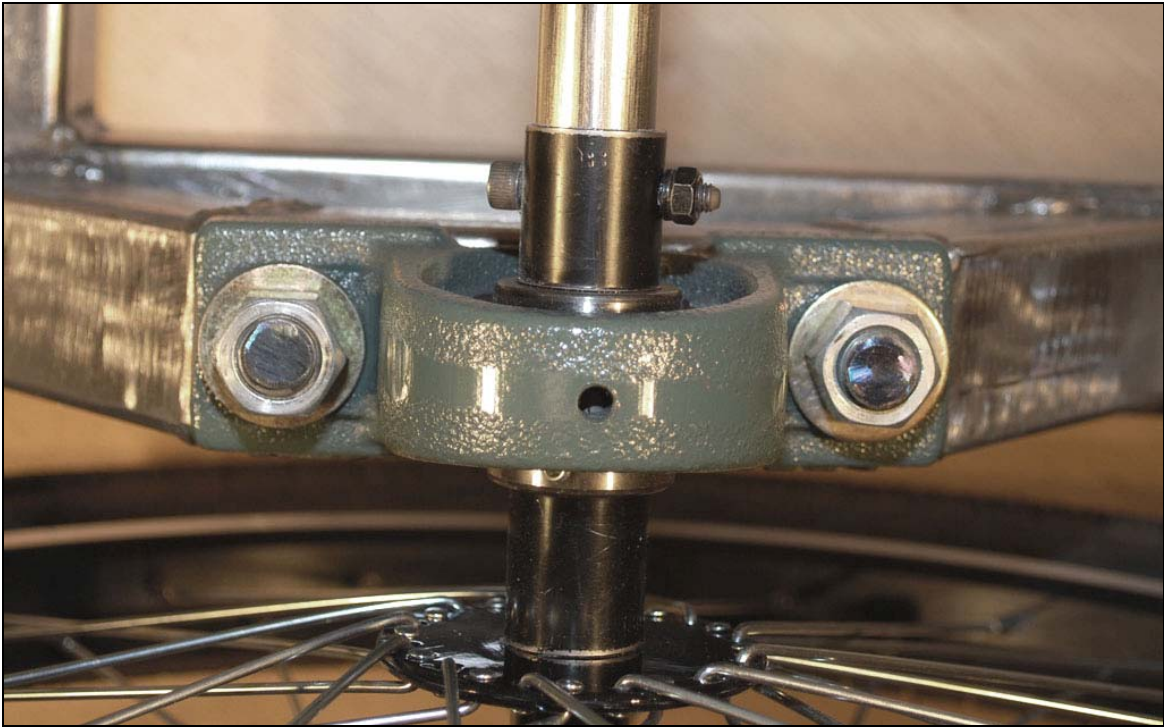


Figure 97 – A bolt locks the axle in place

With the small tube still clamped tightly to the axle, punch and drill a 3/16 inch diameter hole through both the clamp tube and axle so you can insert a bolt as shown in Figure 97. Once the bolt is installed, the axle will not be able to move at all. If you drill the hole on a bit of an angle, this will not be a problem, but the tube will only line up one over the holes. To remember which way it goes, just tap a few identifying marks using your punch for each side.

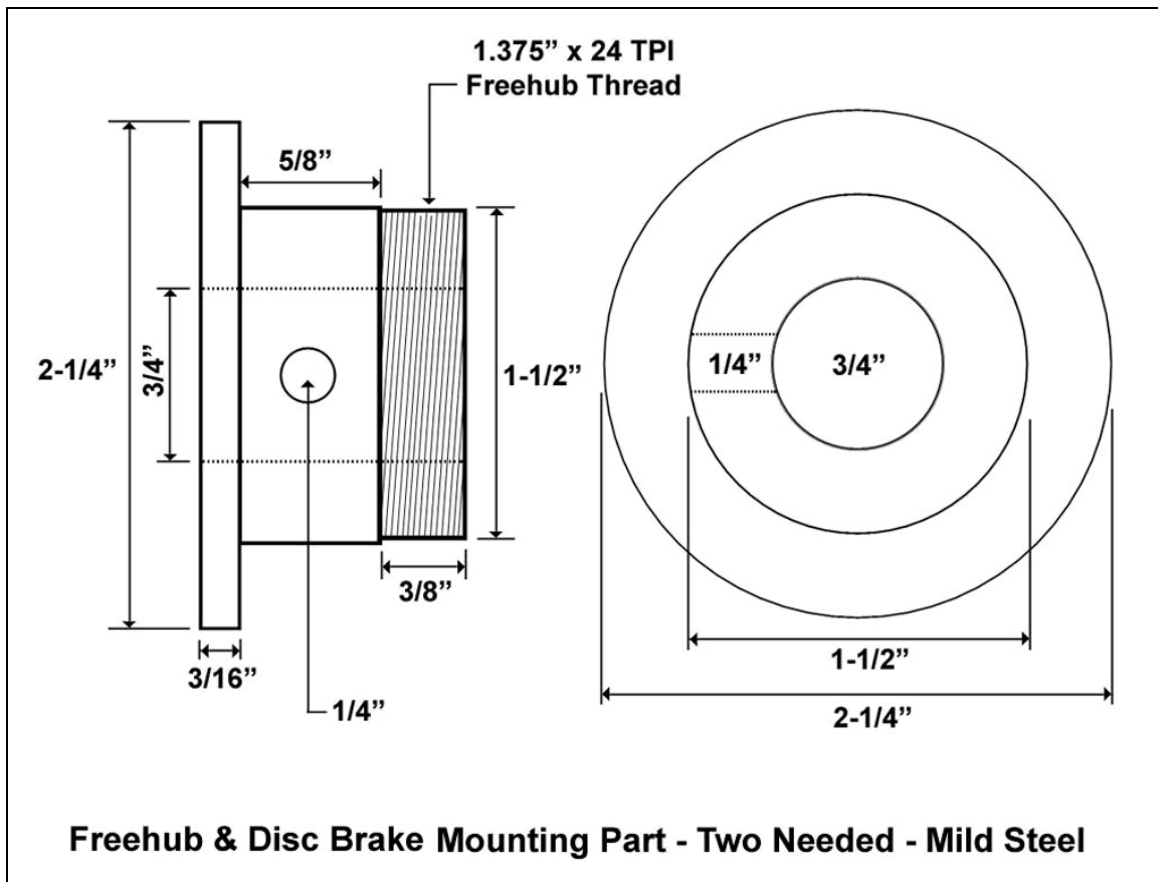
Free Hub and Disc Brake



Figure 98 – A freehub and the mounting adapter

Figure 98 shows the machined part that will mount the freehub and the disc brakes to each rear axles. This part is simply a copy of a typical rear bicycle hub with an included flange to allow the installation of a disc brake. The hole drilled through the part is $\frac{3}{4}$ inch so that it can slide onto the $\frac{3}{4}$ rear axle, and it is held securely in place by a $\frac{1}{4}$ inch bolt placed in a hole through the part and the axle.

When you visit the machine shop to have a pair of these parts made, print out Drawing 3 and Figure 98 and bring along the actual freehub and the original bicycle hub you removed the freehub from as a reference for thread size. As you can see by reading ahead a bit, I chose to drill and tap the holes in the flange to mount the disc brake myself, but if you want to avoid that step, you could ask the machine shop to have this done as well. If you do this, make sure you have an exact drilling pattern, or bring one of your brake discs along for reference. Drilling and tapping your own disc brake holes is not difficult though, and the tool you will need can be purchased at any hardware store for a few dollars.



Drawing 3 – The freehub and disc mounting adapter

Print out Drawing 3 and the actual part photo from Figure 98 when you are having the freehub and disc brake mounting parts made. It is also a good idea to bring the freehub and the disc brake along with you to the machine shop for reference, especially due to the freehub threads. If you plan on having the machine shop drill and tap the disc brake holes, then add the correct bolt circle to the drawing, or hand them the disc and explain how it will bolt to the flange.

Not all disc brakes have the same bolt circle, and the so called "standards" are constantly changing, so having the discs you plan to use before drilling the holes is a good idea. The part is not difficult to machine, so it should be fairly inexpensive to have done, and if you plan on experimenting with rear drive trikes in the future, this really is the ultimate part to have around, so you may even consider having more than two made.

Although the plan calls for two identical parts, you can actually leave out the 3/8 threaded area on one of the parts, as there is only a single freehub used - the other adapter really only needs to carry the disc brake. It may actually cost the same to have both parts made identical due to the time it takes to setup a

lathe for thread cutting, so you might as well have both parts made the same. Having both parts ready to take a freehub will give you the option to make the trike into a tandem later, or to experiment with a rear mounted motor. You will notice that I actually mounted a BMX freehub on my other adapted so I could later convert the LodeRunner into a tandem vehicle with independent drive for each rider.

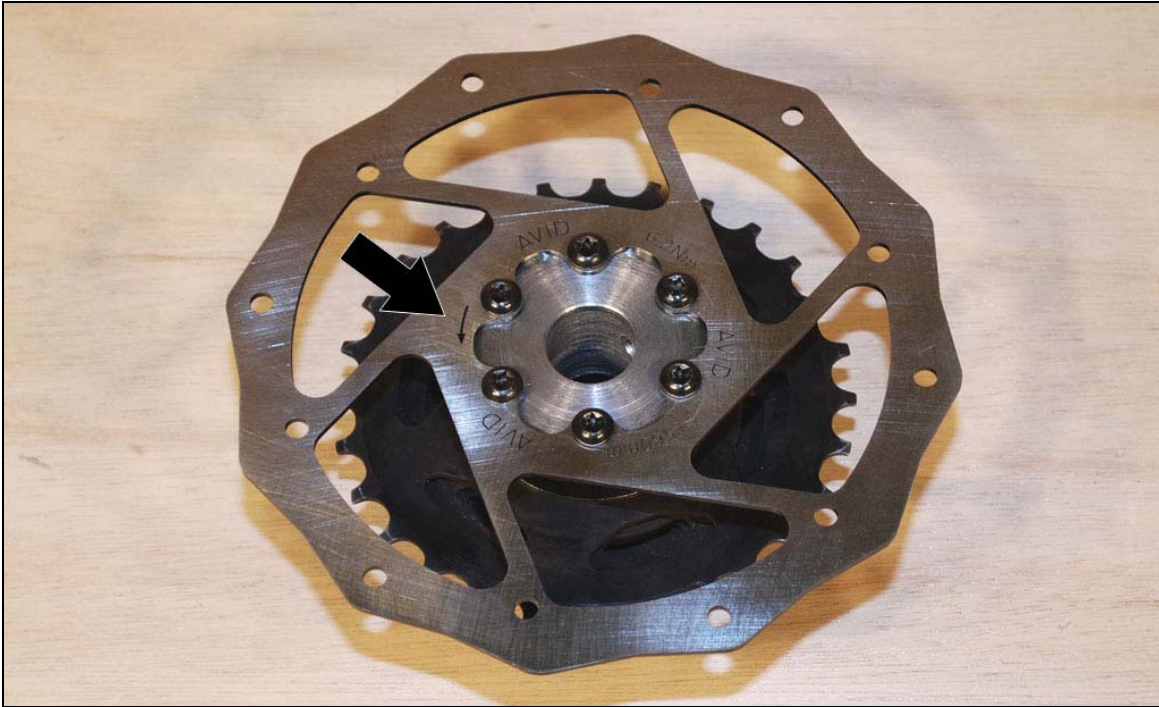


Figure 99 – Installing the freehub and disc brake

I decided to drill and tap the holes for my disc brake in order to save a few bucks off the machining job on the freehub mounting parts. To mark the holes, I printed out a template that matched the bolt pattern on the disc brake and then punched the holes through the template onto the part for drilling. If you did not receive bolts with your disc brakes, then use quality high grade bolts with a fine thread with a length of 1/2 inch. The bolt should be the largest possible size that will fit through the disc brake bolt hole, and will most likely be a metric bolt. As shown in Figure 99, I drilled and tapped three of the six holes, and the disc brake is test fitted to the freehub mounting part taking into account correct rotation as indicated by the arrow.

Threads on freehubs are common on older bicycles and department store cycles. I recommend that you purchase a new 5 or 6 speed freehub, as you never can tell how long a used one will last. Ask for a thread on Shimano style freehub.



Figure 100 – Setting up the freehub and discs

The trike is driven by the right rear wheel, and brakes work on both wheels. Because of this, the freehub cluster must be on the right axle facing the right side of the trike as shown in Figure 100. A keen eye will also notice that I have a single speed BMX freehub mounted on my other adapter on the left axle. Because freehubs only engage in one direction, they will always face the right side of the vehicle (you can easily test this by spinning one).

The right side (main drive) freehub needs to be as close to the center of the frame as possible to make the chain run on a fairly straight line from the front chain ring. Of course, you don't want it so close that your disc brake rubs on any part of the frame or the inner bearing mounting plate, so it will need a little bit of space as shown later in Figure 102. Before you drill any holes, read ahead until you completely understand how the transmission and braking system needs to work.



Figure 101 – Drilling a hole to secure the adapter

When you have read ahead and fully understand the goals of the transmission, you will need to drill a $\frac{1}{4}$ inch hole through both the adapter and the axle in order to install the securing bolt. Since your adapter already has a $\frac{1}{4}$ inch hole drilled through it, it is only a matter of placing the adapter where it needs to be on the axle and then running your $\frac{1}{4}$ inch drill bit into the hole to get it started.

The machined adapter can then be moved out of the way so you can drill the rest of the way through the axle. Figure 101 shows the start of the axle drilling for the left side (brake only) adapter. In my design, I added a BMX freehub for an optional future tandem or motor drive.

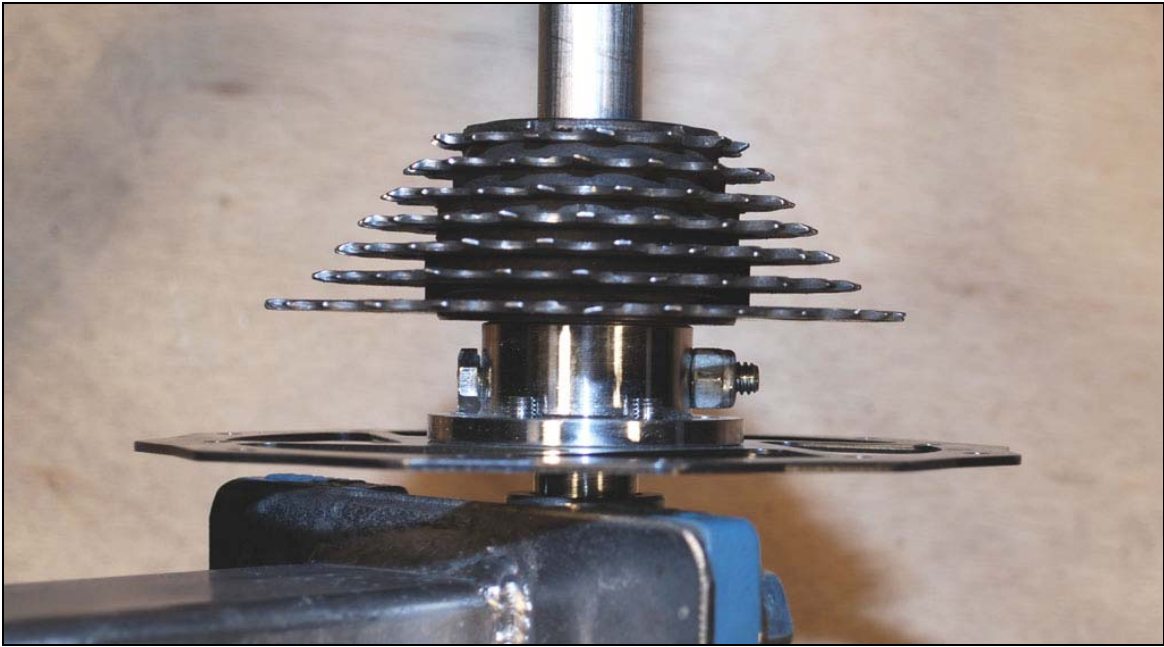


Figure 102 – The main drive freehub and disc

Since your front chain ring is on the right side of the frame, the main drive freehub cluster will be as well. As shown in Figure 102, the adapter should be as close to the inside of the frame as possible without having the disc rotor rubbing on anything. A clearance between the disc and the bearing of about $\frac{1}{4}$ inch should be safe. Also shown in Figure 102 is the high grade $\frac{1}{4}$ inch bolt that is fit through the hole drilled into the adapter and axle.

If you are using a freehub or sprocket on the left side of the trike, then it should be as close to the frame as possible, facing the same orientation as the right side. The left side disc brake rotor can be anywhere on the axle, since the disc caliper can be easily adapted anywhere. Basically, keep all drive systems as close to the inner bearings as you can.

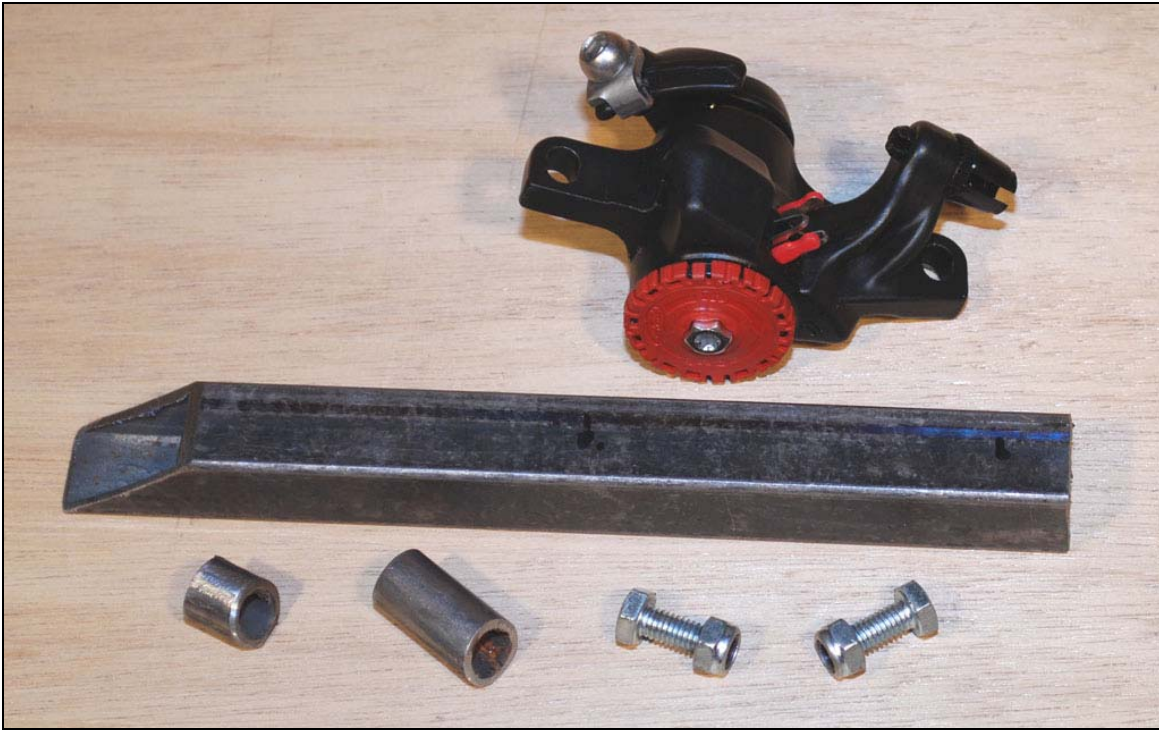


Figure 103 – Creating a disc brake mount

The LodeRunner is designed to use a pair of rear disc brakes for maximum stopping power. Disc brakes come in many styles and shapes, but you should have no problem adapting any of them to the frame. I do recommend that you keep both brakes and rotors the same so braking will be smooth and evenly distributed. I purchased a pair of universal disc brake kits, which had adapters for both front fork and rear frame mounting. Since you will need to create your own mounting system, remove any extra adapter from the brake hardware and start with the basics as shown in Figure 103 (top).

The mounting system needed for your disc brakes could be radically different than mine due to the ever changing style of brake hardware, so there is no point in providing dimensions for the small parts I use to secure the hardware to the frame. The goal is to simply place the brake hardware over the disc so that both pads grip the disc in the appropriate place just like they would on a regular bicycle installation. I will show you how I did this in the next few steps using the $\frac{3}{4}$ inch tube and bolts shown in Figure 103.

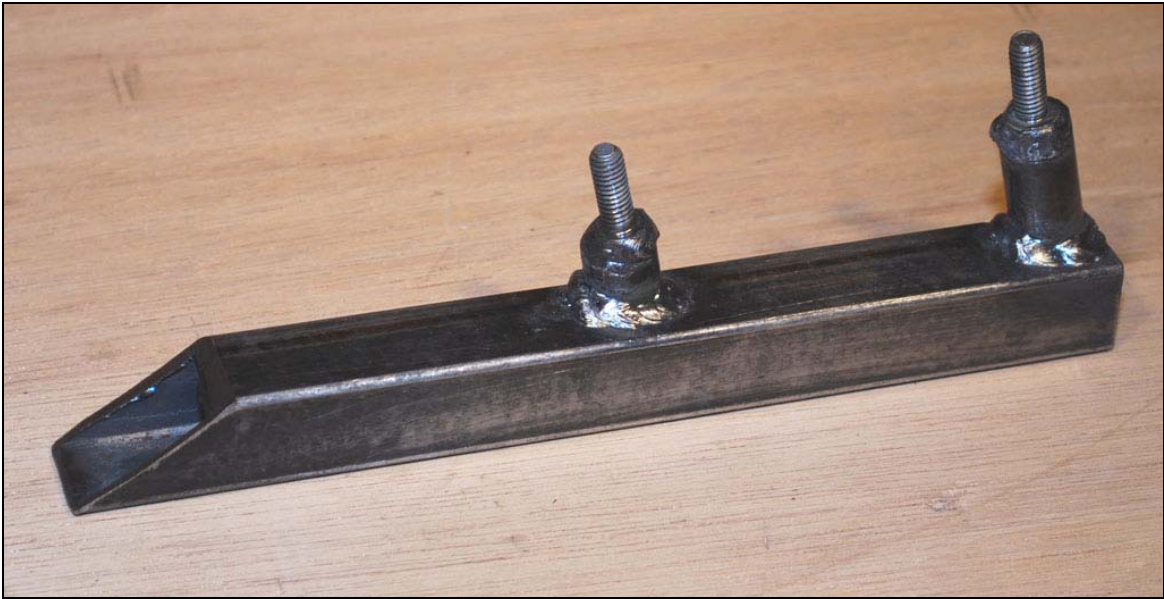


Figure 104 – Adding the bolts to the arm

Before you mount the brake calipers, you will need to experiment with different places to mount the hardware. You want to place the calipers in such a position that they grip the disc fully and allow easy cable routing towards the brake levers. Also, consider the cargo space over the discs, ensuring that your cables will not have to feed through the flatbed.

I played around awhile and found that my brake hardware would live perfectly directly over the discs. There would be no problem with the cargo area, and the cables were heading towards the front of the bike, which was also good. The small length of $\frac{3}{4}$ inch square tubing shown in Figure 104 was cut to a length that would allow the caliper to be fastened to the frame. The two bolts were welded to the small bits of $\frac{3}{8}$ inch tubing to allow adequate clearance of the bodies.



Figure 105 – This is the left side brake mounting system

Figure 105 shows how the $\frac{3}{4}$ tube will carry the brake hardware over the disc. This system is only good for the left (non drive) side of the trike due to the position of the rotor. For the right side, I will have to experiment a little more and come up with a different approach. It may take a little experimentation to get your brakes set up, so take your time and see what works best.

Don't use tubing less than $\frac{3}{4}$ inch for mounting a disc brake or it may not be strong enough. Gussets may help if you think the arm is not strong enough. Also, a nice trick to help center the brake is to use a tie wrap to force the lever shut in order to clamp the brake to the disk. When the brake is clamped to the disc with both pads over the brake area, this is the optimal alignment point.

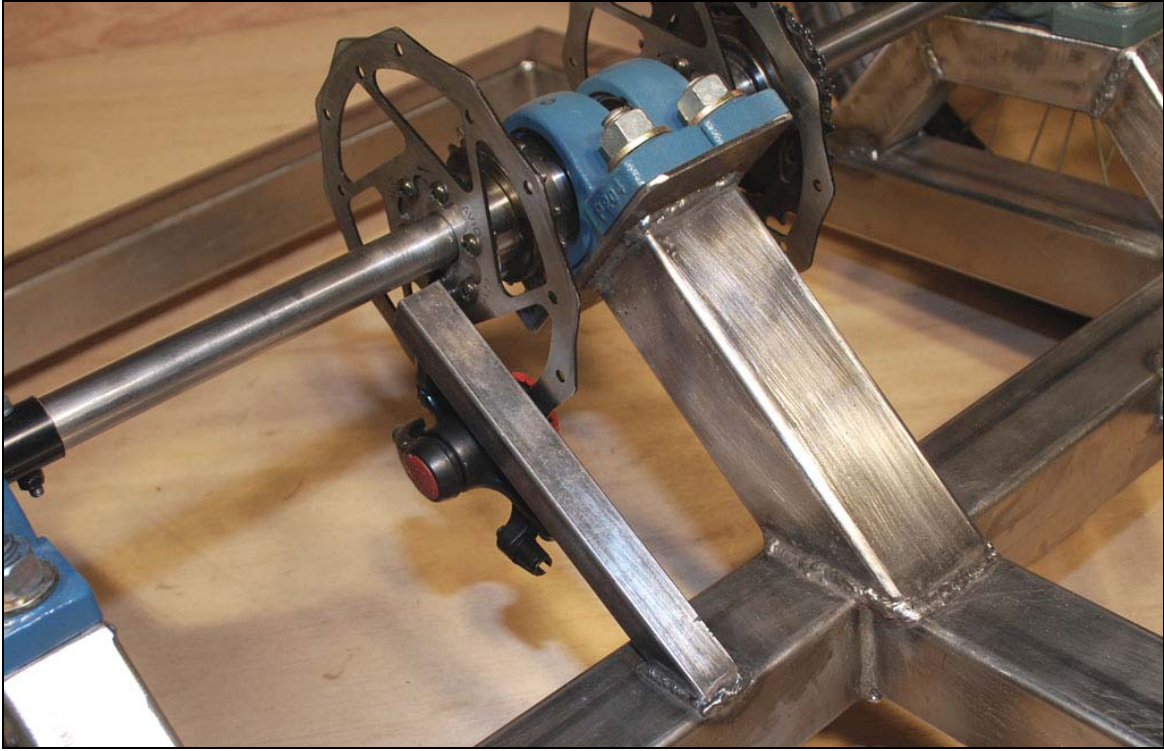


Figure 106 – Left side brake installed

Once I played around and came up with a good system for mounting the left side brake, I bolted the hardware in place and then tied the brake lever closed so it would center on the disc. With the brake securely clamping the rotor, I carefully tack welded the arm to the frame as shown in Figure 106 and then released the lever.

After the lever is released, the wheel should freely spin with very little friction. Some rubbing is actually normal as many disk brakes have a self centering mechanism. Friction should not be so much that the wheel slows down instantly, but some rubbing is fine.

If you are welding with your disc brake hardware installed, cover it up with some cloth or painting tape to keep it safe from welding spatter. Welding the arm in place with the brake engaged was certainly the best way to ensure proper alignment.

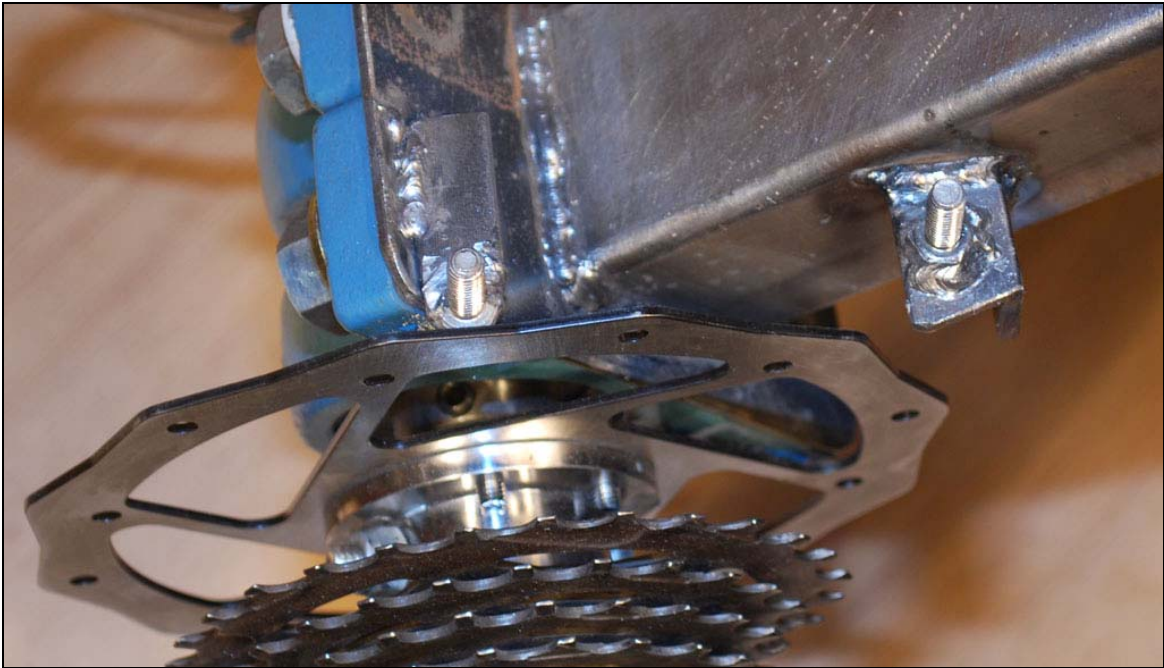


Figure 107 – Mountings for the right side brake

The mounting arm system used on the left side brake would not work on the right side due to the position of the rotor, which was very close to the frame. This actually made mounting the brake hardware easy, as it could be bolted close to the frame on some small bits of angle iron as shown in Figure 107.

The same “clamp and weld” method was used to find the optimal brake position, welding the small tabs in place with the hardware biting into the rotor. I wrapped the brake hardware in an old work glove after it was in place so the welding process would not damage the part. Watch out for heat if your brake hardware has plastic parts!

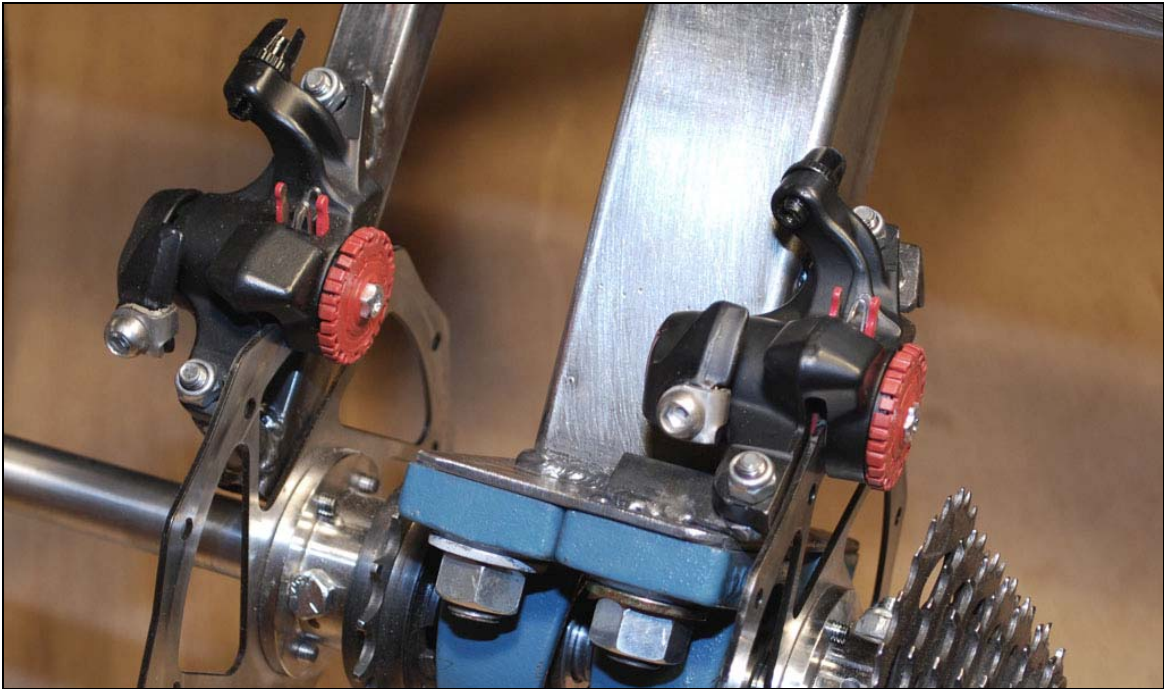


Figure 108 – Both brakes installed

The two brake calipers are shown mounted to the frame in Figure 108. Although both are using radically different mounting schemes, both brakes are facing the same direction and have ample grip on the rotors. The cables make a nice clean line towards the front of the frame, which make adding the cables a lot easier. If you find the brakes are rubbing excessively after welding the support hardware, you should be able to make fine adjustments by moving the hardware slightly on the bolts. If you are really in trouble, drill the hole up to the next size to allow a little wiggle room when centering the brakes.

Installing the Rear Derailleur



Figure 109 – Mounting the rear derailleur

The rear derailleur needs to be positioned under the drive freehub in the same way it would be on a typical bicycle. Before you add the rear derailleur, take a look at a working bicycle so you can understand how the derailleur works and how it needs to be aligned with the rear freehub. The concept is exactly the same on the LodeRunner, although you will need to get creative to place the derailleur in the correct position. The derailleur shown in Figure 109 is a small bodied road bike style, but any derailleur will work. I chose the short body derailleur because the ground clearance is fairly tight under a 20 inch wheel. For city driving, this is not really an issue, but if you plan to hit the back trails, a shorter rear derailleur is probably better. Also shown in Figure 109 is a length of $\frac{3}{4}$ inch square tubing to use as derailleur mount.



Figure 110 – You won't need this part anymore

The LodeRunner has no stationary threaded rear axle or dropouts, so the slotted arm shown in Figure 110 can be cut from the derailleur. The goal is to place the rear derailleur in the same position over the rear freehub as would normally be, so this arm needs to be cut away in order to achieve this. Ensure that this part of your derailleur is made of steel, not aluminum or you will not be able to weld to it.



Figure 111 – Making a derailleur mounting arm

The tab that holds the spring loaded body on the rear derailleur was welded to the end of the derailleur mounting arm shown in Figure 111. There are many ways you could get the rear derailleur into the correct position, but this was the easiest method I could come up with, and works perfectly. A cut off fork leg may also work to make the derailleur mounting arm. As for the length of the arm, it is based on your derailleur, so cut more than you need and then

trim it down to fit.

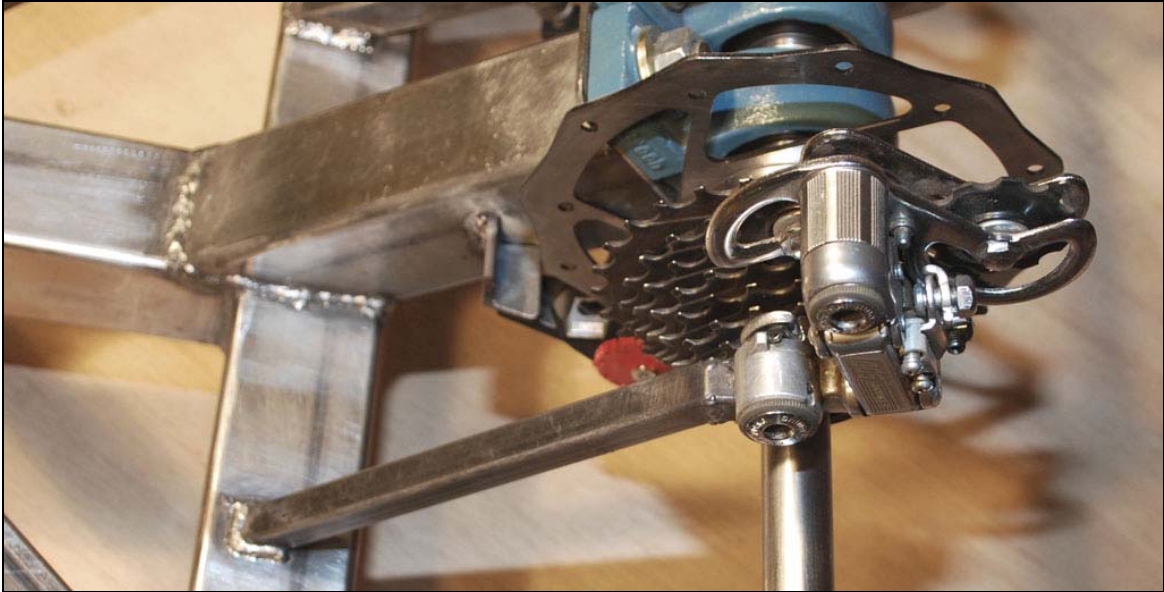


Figure 112 – Derailleur fully installed

If you have never worked with a rear derailleur before, only tack weld the mounting arm to the frame at first so you can test the range of motion over the freehub. Figure 112 shows how the mounting arm places the rear derailleur in the exact position it would be on a normal bicycle. In its relaxed mode, the derailleur is sitting over the smallest chain ring on the freehub.

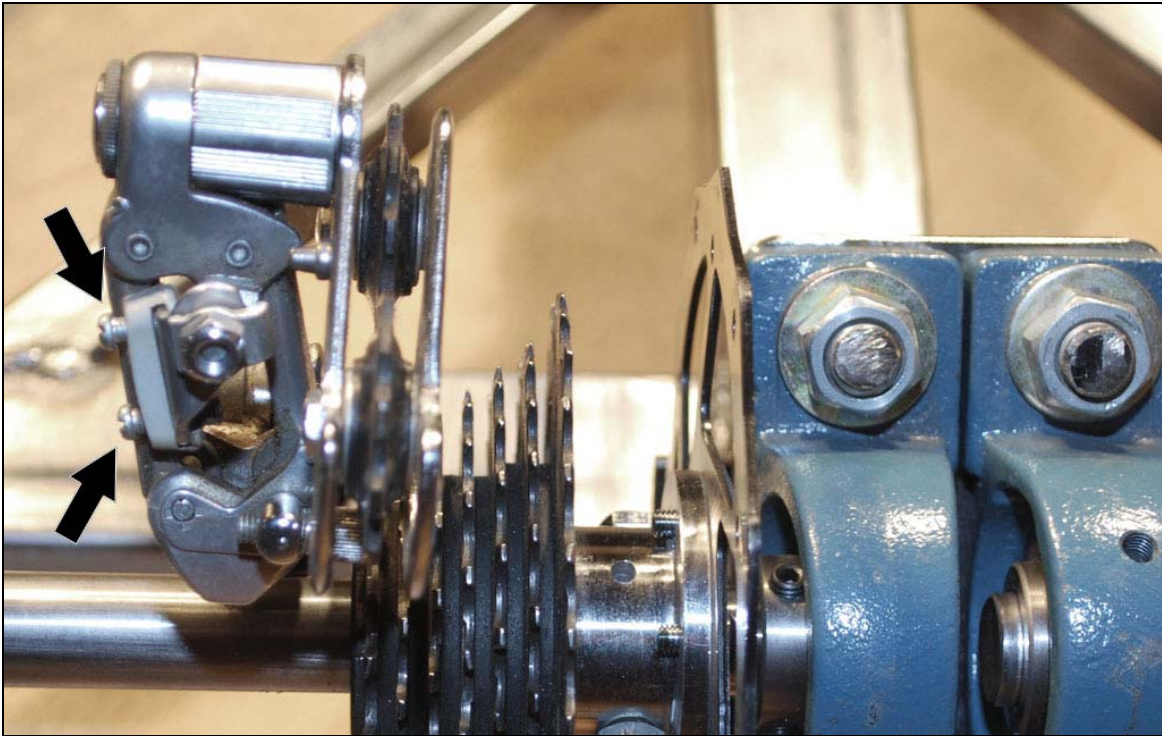


Figure 113 – Adjusting the rear derailleur

The front and rear derailleurs will have a pair of adjusting screws to limit the range of motion over the chain rings (arrows in Figure 113). Both of these screws will need to be adjusted so that your derailleur only travels from the small ring to the largest and not any further. Too little range and you will miss certain gears.

Too much range and your chain will shift right off the freehub. Turn the little screws and you will see how they affect range of motion. Notice that my rear derailleur is sitting right over the smallest chain ring when it is in its default (no cable) position. The cable will pull it to the right over the larger chain rings until the limit screw locks it out.

Building the Adjustable Bottom Bracket



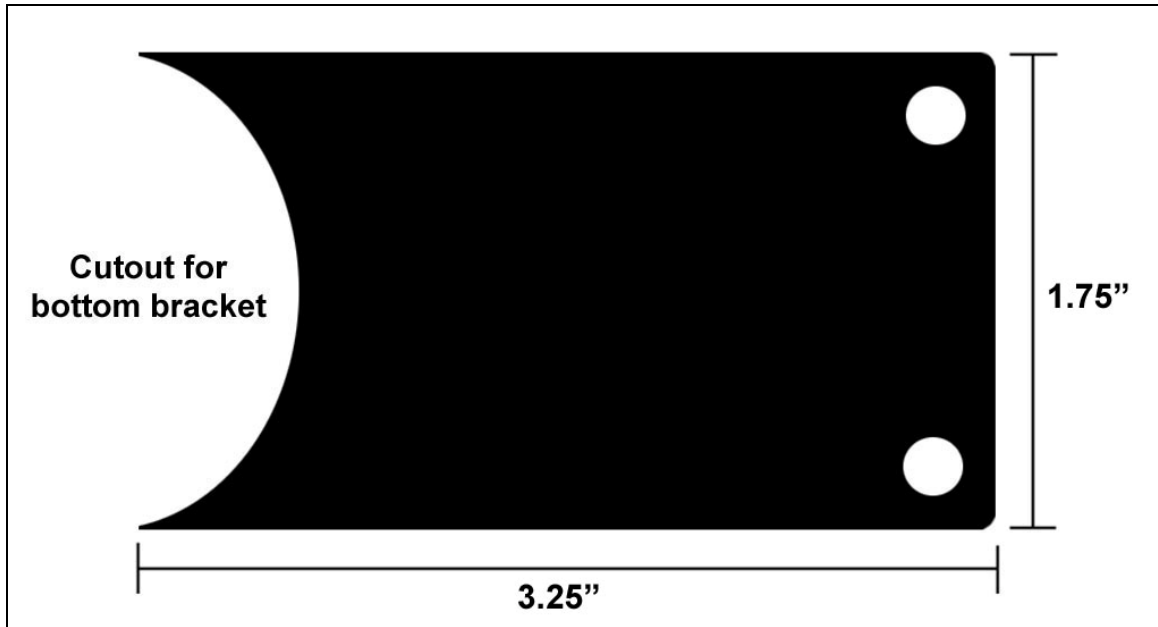
Figure 114 – Removing the bottom bracket and seat tube

The LodeRunner includes an adjustable bottom bracket so that riders of varying leg lengths can adjust the distance between the seat and pedals for optimum comfort and performance. Moving the bottom bracket is better than moving the seat because the steering system would also have to move with the seat, creating a very complex and difficult design to adjust linkage system. By moving the bottom bracket, we only have to deal with the front derailleur, which just happens to be part of the sliding bottom bracket, so adjustments can be made easily. Any difference in chain length can be taken up by the rear derailleur's spring mechanism, so the entire process is painless and easy.

Since the front derailleur requires a length of the seat tube (derailleur tube) to hold the clamp in place (as it did on the original bicycle frame), we will leave a bit of this tubing when we cut away the bottom bracket from the scrap bicycle frame as shown in Figure 114. Cut the chain stays and down tube from the bottom bracket and leave at least 12 inches of the seat tube intact, so you will have plenty of room to place the derailleur no matter what type of front chain ring you plan to install. The extra length of seat tubing will simply be cut away once you have the front derailleur in place.

The bottom bracket and included seat tube will be mounted to the main boom with a clamp arrangement that allows the assembly to be placed just about anywhere on the boom to allow riders of varying heights to ride the bike. The two plates shown in the next drawing will form the sides of the clamp that will

hold the bottom bracket against the side walls of the main boom as they are forced together by two bolts.



Drawing 4 – Adjustable bottom bracket clamps

The bottom bracket and front derailleur tube move together along the main boom, so you do not have to worry about the position of the derailleur over the chain ring. The chain is cut to the perfect length once the bottom bracket has been adjusted for the main rider, but will still allow a few inches of adjustment in either direction without a chain alteration due to the spring loaded rear derailleur. Of course, the difference between a 6 foot 5 inch adult versus a 4 foot tall child will likely require some chain adjustment, but this can be done in less than a minute with an inexpensive chain link tool.

Cut two 3/16 inch thick pieces of plate or sheet to make the shapes as shown in Drawing 4. The round area is cut to conform to whatever size bottom bracket you decided to go with, and the two bolt holes will be drilled for 1/4 inch bolts. The bolt holes are drilled at the edge of the plates so that there is 1/8 inch of material between the hole and edge of the plate. These two plates will form a "vice" that will clamp the bottom bracket to whatever position on the main boom you want.



Figure 115 – The freshly cut bottom bracket

The bottom bracket shown in Figure 115 was freshly cut from the donor frame and will need some cleanup before it can be used. Use your grinder and remove the leftover frame tubing to clean up the shell. Start with a heavy disc and then clean up the shell (including the paint) using a sanding disc. Welding over paint creates horribly toxic fumes that will stink up your work area!



Figure 116 – Fix any open welds after cleanup

Depending on your donor frame, there may be a few places on the bottom bracket that need filling. On mine, there were two small holes where the chain stays were welded as well as a gap on the seat tube joint. As shown in Figure 116, I fixed the seat tube joint gap with fresh weld and filled in the two small holes.

Take a look at the cups that screw into the bottom bracket. You will notice that the right side is a single unit (shown in Figure 116), while the left side includes both a threaded cup and locking ring. As a general rule, never remove the right side cup as it is reverse threaded and difficult to remove. By leaving it installed, you will always know which side of the bottom bracket gets the chain ring, and not have to worry about cross threading the wrong cup into the threads. Keeping the cups installed also protects the threads when welding.



Figure 117 – Trace the bottom bracket shell

Trace around the bottom bracket shell to draw a line on the plate as shown in Figure 117. The marker line should meet the corners of the plate to ensure that you don't cut out too much off of the plate when grinding out the rounded area. If you take too much metal away from the plate, there will not be enough room between the bottom bracket and the clamping bolts for the main boom.

When grinding out the traced circular area for the bottom bracket, place both plates in the vice so they can be done at the same time and this will ensure that both plates are exactly the same size. Try to make the gap as small as possible around the bottom bracket shell so that there is less distortion as the plates are welded. If the bottom bracket becomes overly distorted, it will be a serious challenge trying to screw the hardware back into the bottom brackets without stripping the threads.



Figure 118 – Clamp plates ready to weld

The two bottom bracket clamp plates are shown in Figure 118 after grinding and cleanup. Both are the same size, and conform to the bottom bracket shell with minimal gap.



Figure 119 – Setting up the clamp plates for welding

In order to get the two clamping plates aligned with each other and at the correct spacing, a bit of frame tubing can be clamped between the two plates as shown in Figure 119. This will allow you to set the bottom bracket into the correct position for tack welding, as well as ensure that both plates are aligned

with each other so the bolt passes easily through both holes. I also placed a sheet of paper (folded in half) between each plate and the side wall of the tubing to allow a little clearance between the clamp plates so that the unit is not so difficult to slide when making adjustments. Without the small gap, it is easy to scratch the paint if you plan to move the bottom bracket around a few times.



Figure 120 – Setting the shifter tube angle

As shown in Figure 120, I used an adjustable square set to the required 56 degrees in order to set up the bottom bracket and derailleur tube to place two small tack welds at the top of the joint. It may be a bit tricky to get the first tack weld in place while holding the bottom bracket in position, but once this is done, the rest is easy.

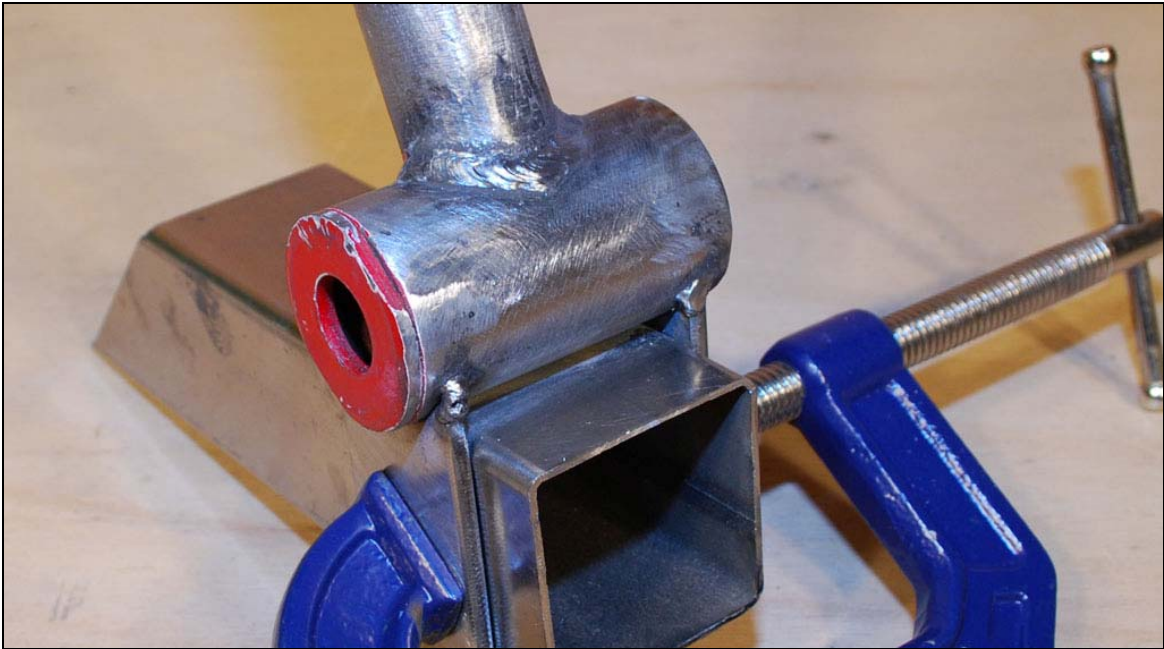


Figure 121 – Initial tack welds hold the plates

Figure 121 shows the first tack welds done at the top edge of the clamp plates to secure the parts together. Make sure the derailleur tube angle is close to 56 degrees and that the bottom bracket is at 90 degrees to the square tubing as viewed from the top. Welding is only done on the outside of the joint, not between the plates. If the inside of the joint is welded, the weld bead will not allow the bottom bracket to sit directly on the frame tubing and could cause alignment problems. Because of the way the clamp system works, there would be no added benefit from welding the inside of the joint anyway.



Figure 122 – Welding the clamp plates

Once your bottom bracket is set up at the correct angle and crosses the square tubing at 90 degrees, remove the tack welded parts from the square tubing and complete the welding as shown in Figure 122. Only the outside of the joint is welded. If you are worried about welding spatter or have a tendency to “wander” when welding, it may be a good idea to screw a cup into the bottom bracket shell to protect the threads.



Figure 123 – Drilling the bolt holes

The two plates will form a vice-like grip on the frame tubing when the 3/8 inch bolts are tightened. To drill the holes into the plate, draw a line that represents the bottom corner of the frame tubing as shown in Figure 123. Now you can punch and drill the bolt holes using the line as a guide that will allow you to make sure the holes stay below the line. If the holes are not below the line, you will not be able to pass the bolts through both plates because they will hit the frame tubing instead.



Figure 124 – Completed bottom bracket assembly

Installing Cranks and Chain

Once your bolt holes are drilled, place the bottom bracket assembly on the frame boom and tighten the bolts until the unit is secured to the frame. Don't over tighten the bolts so that they crush the tubing – just enough to hold the unit in place. Now you can install a chain ring and front derailleur to figure out how much of the excess tubing can be removed. If you plan to experiment with different front derailleur types and crank sets, then leave the derailleur tube long for now and cut it down later on.

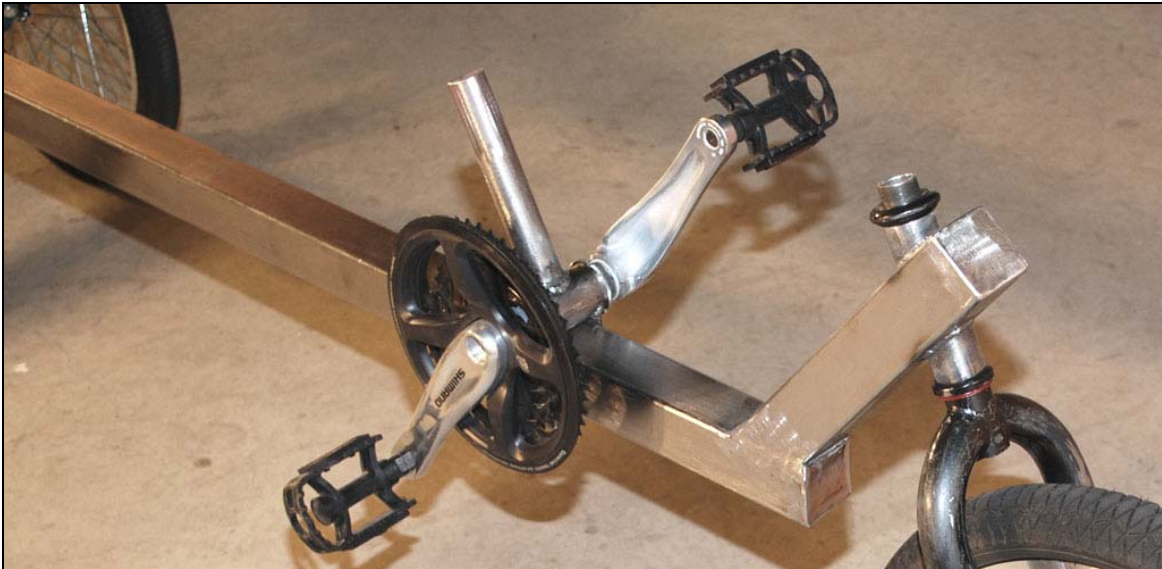


Figure 125 – Installing the cranks set

If you take a close look at the axle from your crank set (does not apply to single piece crank sets), you will notice that one side is actually slightly longer than the other. The long side of the axle goes on the right and helps place the chain rings away from the frame. Figure 125 shows the adjustable bottom bracket and crank set installed on the frame.

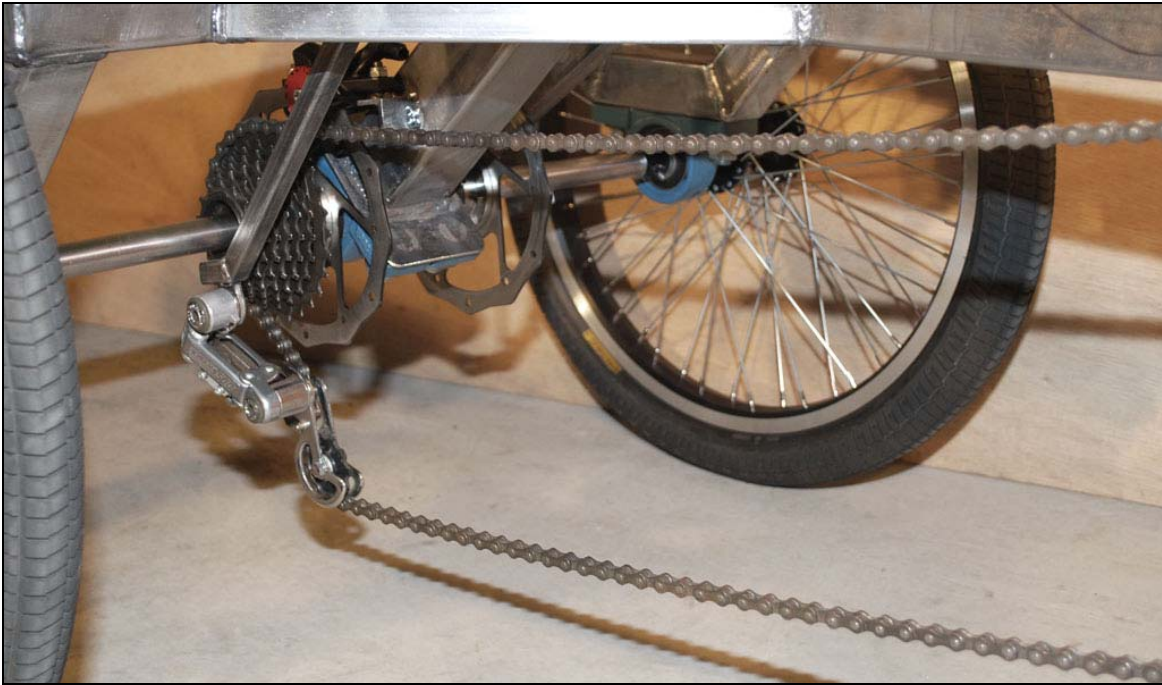


Figure 126 – Putting together the chain

The LodeRunner needs a long bicycle chain made up of two or more normal cycle chains to make the distance. I recommend that you purchase chain link tool from your cycle shop, as this will make building chains extremely easy and will not cost much at all. I also try to use new chain when building vehicles that I want to be reliable, especially when travelling far from home. All chains to join need to be the same width and designed for a derailleur system. Single speed chains are a lot wider than speed chains and will not fit through the derailleur body.

When initially jointing the chains, I like to put the chain on the two largest chain rings as shown in Figure 126. Since this is the longest distance the chain will have to travel, this is how you determine its maximum length. If your chain is too short, the rear derailleur will be pulled awkwardly towards the front of the trike on the two largest rings and if your chain is too long, it will flop on the ground when placed on the two smallest rings. There is balance there somewhere!



Figure 127 – Picking up the slack chain

The return chain is the chain that exits the bottom of the front chain ring and enters the bottom of the derailleur. This side of the chain will never be under any tension, so it will tend to flop around, even bounce off the ground if you are shifted in the two smallest rings. To cure this chain flop annoyance, a simple v-belt idler pulley is placed in the center of the frame as shown in Figure 127. This pulley will keep the chain out of the dirt and make the completed trike look so much better than if the chain was left hanging in the wind. Any 2 or 3 inch pulley with a center bearing and chain sized groove will work fine for this task. Yes, you could even hack up another rear derailleur and make something out of the small plastic wheels.

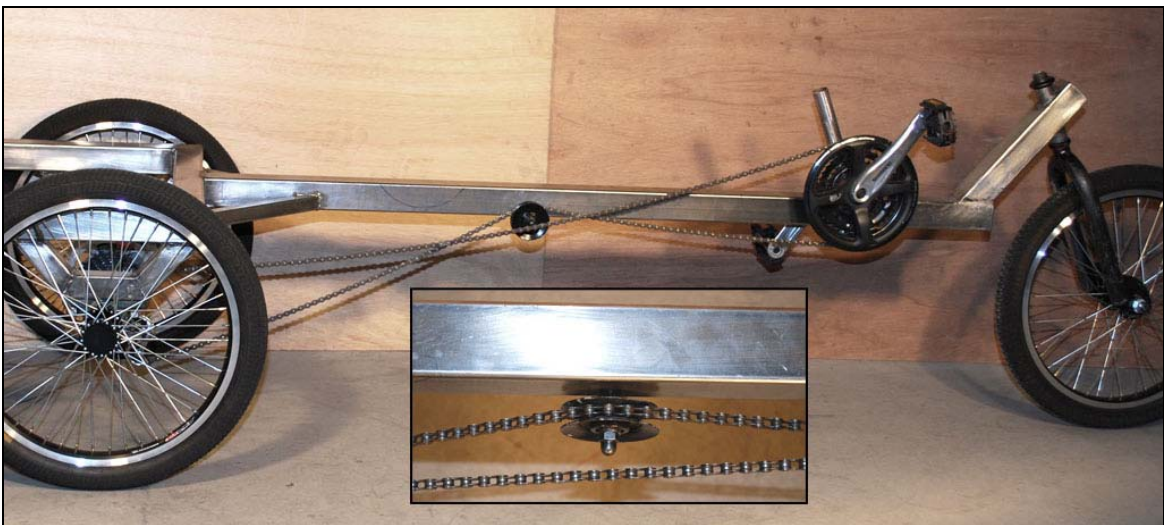


Figure 128 – Return chain pulley installed

Figure 128 shows how much better the chain line looks now that the idler pulley is directing the return chain to the back of the trike. Before I added the pulley, the chain was hanging very close to the ground, especially when on the two smaller chain rings.

Building Seat Mounts



Figure 129 – “Fishing” for a good seat

With such a simple frame design and all of that seating room, you could add just about any kind of seat you wanted to the LodeRunner. I usually make my seats out of foam and wood, but this time I wanted more comfort than anything else, so I hit the local hardware store and found a fishing boat seat on sale for less than \$50. This type of seat would not be good for a two wheeler or a racing cycle, but worked very well for the LodeRunner. The seat also came with a rotating platform as shown in Figure 129, and I decided to hack it up to make a seat mounting system. Don’t try to install a rotating seat on a bicycle, or you will be thrown from the seat on the first sharp corner!



Figure 130 – Hacking the base to make a mount

The original rotating base from the boat seat was cut apart and reconfigured into a vice-like mounting system that would allow the seat to be placed on the frame at a comfortable angle and welded solid. Figure 130 shows how this makeshift clamp was made out of the two plates that came with the original seat rotator.



Figure 131 – Finding the best seat position and angle

Seat angle is another personal preference. On a racing machine, I like to be way back in the recumbent position for better aerodynamics, but on the LodeRunner, a 25 degree decline seemed to be just right. Figure 131 shows how the hacked clamp system hugs the frame as I prop up the seat using a few tubes to test different positions and angles. Placing the seat just ahead of the rear frame box will allow full utilization of the cargo space, and still left plenty of leg room, even for a taller rider.



Figure 132 – Securing the seat mounting base

Once I found the most comfortable seat position, the base was welded to the frame using a few beads as shown in Figure 132. Use whatever method and seat you think suits your riding style – there are so many options available for a trike like this. Once I even used a bucket seat from a car on a trike! Surprisingly the car seat was not all that heavy and very comfortable. Some things to keep in mind when choosing a seat are: the weather (rain), how much you will sweat, and how the durable the material is.

Steering



Figure 133 – Removing the head tube and down tube

The LodeRunner has indirect steering, which connects the handlebars to the front forks via rod and ball joints (spherical bearings). Direct steering where the handlebars connect directly to a gooseneck placed in the front fork set would be impossible on a trike which puts the rider so far back from the front wheel. For this reason, we will require a second head tube placed in the center of the frame just ahead of the seat at the same approximate angle as the front head tube. To ensure you know which head tube I am referring to, from now on I will refer the front head tube (the one with the front forks installed) as simply the "head tube", and this new head tube as the "pilot's head tube", since it is the one that connects the handlebars.

As shown in Figure 133, that frame you butchered for the bottom bracket earlier will come in handy one more time. If the down tube is at least 1.25 inches in diameter, then cut the head tube and down tube from the frame as shown in Figure 133. If your down tube is not at least 1.25 inches in diameter, then you will need to find some appropriate tubing to replace it. This tube will support the pilot's head tube and handlebars, so it needs to be fairly sturdy.



Figure 134 – Trimming the down tube

The exact position of the pilot's head tube is up to the builder, but as a general rule the pilot's head tube and front head tube should be at the same approximate angle, and the pilot's head tube will be placed 6 to 8 inches in front of the seat. The exact position will be determined by holding the handlebars at the most comfortable position later in the project. The down tube shown in Figure 134 has been trimmed to a length of 8 inches, but you might want to work on the next few steps before you cut it down.



Figure 135 – Remove the fork legs

As shown in Figure 135, you will need to find set of forks with a stem of the appropriate length to fit the pilot's head tube. Don't worry about the condition of the fork legs, as they will be removed anyway. However, do ensure that if there is damage, it has not been done to the stem as well. One thing to

note: you want to make sure the bearing races, head tube cups and bearings do work together properly, as there are several sizes used. Throw all the hardware together as a test - the fork stem should turn with almost no friction even when all of the hardware is screwed on tight.



Figure 136 – Trimming the fork crown

Draw a line around the base of the crown as shown in Figure 136, leaving about an inch of material just below the top ridge where the bearing race was located. This will remove some of the heavy tubing that was once needed when the fork legs were connected and supported the weight of the rider. In this steering setup, there will be very little stress on any of the steering parts. The bearing race will tap off of the stem if you bang it all the way around with a chipping hammer.



Figure 137 – Securing the fork stem

The large beefy chunk of fork crown material is really not necessary in our steering mechanism since it will no longer be used to support the front end of a bicycle, only a small control arm, so it can be removed by cutting along the line that you drew earlier. After you have cut the thick stub from the fork crown, a weld must be made all the way around the underside as shown in Figure 137.

If you look closely at the area that you just cut, you will notice that it is actually made up of two tubes that fit together not a single beefy tube. The part you are throwing away would have a welded area just like the one you are about to make in order to ensure the two parts do not fall apart. This weld is very important, and if it is not done, your steering could completely fail since the control arm will only be welded to the outer tube that is fit around the fork stem.



Figure 138 – Control arms and ball joints

The LodeRunner steering system will connect the front forks to the handlebars using a pair of control arms and two ball joints (spherical bearings) so that the exact movements of the handle bars will be transferred to the front forks, giving the feel as if you were holding on to handlebars directly connected to the front forks like that of a regular bicycle.

My ball joints are designed to thread on to a bolt or rod with the appropriate threads, and other types have the bolt already installed on the body of the ball joint - either type will work just fine for this project. The threaded ball joints allow for some fine tuning of the steering alignment, which makes getting the correct rod length a snap. You can also make steering alignment tweaks by adjusting the pilot's gooseneck.



Drawing 5 – Steering control arm dimensions

Drawing 5 shows the dimensions for the two steering control arms you will need to cut form the 1/8 inch thick plate or flat bar.



Figure 139 – Steering control arms completed

The two control arms shown in Figure 139 are just pieces of 1/8 inch thick plate or flatbar cut to the size as shown in Drawing 5. The rounded area at the base of each control arm will form to the crown area on your front steering

system and to one of the legs on the LodeRunner's front forks. Look ahead a few steps to see how this works.



Figure 140 – Pilot's control arm installed

The pilot's control arm is welded to the base of the fork stem as shown in Figure 140. The control arm should be installed at about 90 degrees to the fork stem, close to the base of the stem. Make a solid weld all the way around the joint to ensure that it is secure.



Figure 141 – Pilot's assembled steering system

Once the pilot's control arm is welded to the fork crown, assemble the fork hardware as shown in Figure 141 to complete the assembly. If you have not

yet trimmed the down tube, that's fine as the next few steps will help you determine how long it needs to be.



Figure 142 – Parts needed to make the long gooseneck

The LodeRunner requires a very unique long and straight gooseneck in order to mount the handlebars to the steering head tube. You will not find anything like it on a regular bicycle, so we will simply make our own by using a steel seat post or some mountain bike handlebars to extend a commonly available steel bicycle gooseneck. Figure 142 shows the steel gooseneck I chose to cut along with the slightly curved mountain bike handlebars.

Your goal is to place the gooseneck clamp in a position that will allow your handlebars to clear your legs and knees when pedaling, yet keep your arms and hands in a very relaxed and comfortable position. Any steel gooseneck that fits into the fork stem you used to make the steering head tube will work just fine, but be aware that there are two common sizes - BMX and mountain bike.

BMX goosenecks have slightly smaller diameter tubing and will create a very sloppy loose fit if placed into a mountain bike fork stem. A mountain bike gooseneck would not fit into a BMX fork stem. The seat post or mountain bike handlebar tubing shown in Figure 142 will be used to make the actual extension between the gooseneck stem and the clamp, so this tubing must be made of steel.



Figure 143 – Laying out the extension tube parts

How tall to make your gooseneck is really a factor determined by your body size and the height of your seat from the frame. Just for the record, the tube I used to extend the gooseneck as shown in Figure 143 is 12 inches long and made from an old mountain bike handlebar. Seat post tubing, conduit, or any similar strength tubing will work just fine.

Cut the clamp from the gooseneck so there will be enough material to make a good joint between the extending tube and the base of the gooseneck. As shown in Figure 143, I cut the gooseneck an inch from the stem and ground the area to allow an easy weld of the two parts. The position and angle of the extending tube should place the top of the tube (where the handlebars will mount) directly over the center of the gooseneck tube. This placement of the handlebars will remove all tiller effect from the steering so that the handle bar turns directly on its center axis.

Before you make any cuts or welds, it's a good idea to sit on the seat while the bottom bracket and cranks are installed to see which handlebar position feels most comfortable. Do this by holding whichever handlebars you plan to use as you pedal so that you can find the optimal position. Make sure you have your seat base set up to the height it will be in the final design, including any padding. When you are holding the handlebars at what you think is the optimal position, have a helper measure the distance from the handlebars to the gooseneck and use that as reference. In case you need to make a slight adjustment later, you will be able to move the gooseneck up and down slightly just as it was done on a regular bicycle.



Figure 144 – Completed gooseneck extension

As shown in Figure 144, the handlebar clamp is positioned in such a way that if you drew a line extending from the center of the gooseneck tube, it would hit the center of the clamp; this is why the extender tube is welded in place at a slight angle.



Figure 145 – Choosing the best handlebars

As for handlebars, you are free to use whatever style you think feel best for you. I have found that these old style “Granny bars” are usually perfect for over seat remote steering systems as they curve around you legs to give knee

clearance and put your hands in a very relaxed and natural position. There is also plenty of room for the levers and shifters as shown in Figure 145. Straight handlebars should be avoided as they will not only look out of place, but put your hands higher and your wrists in an unnatural position.

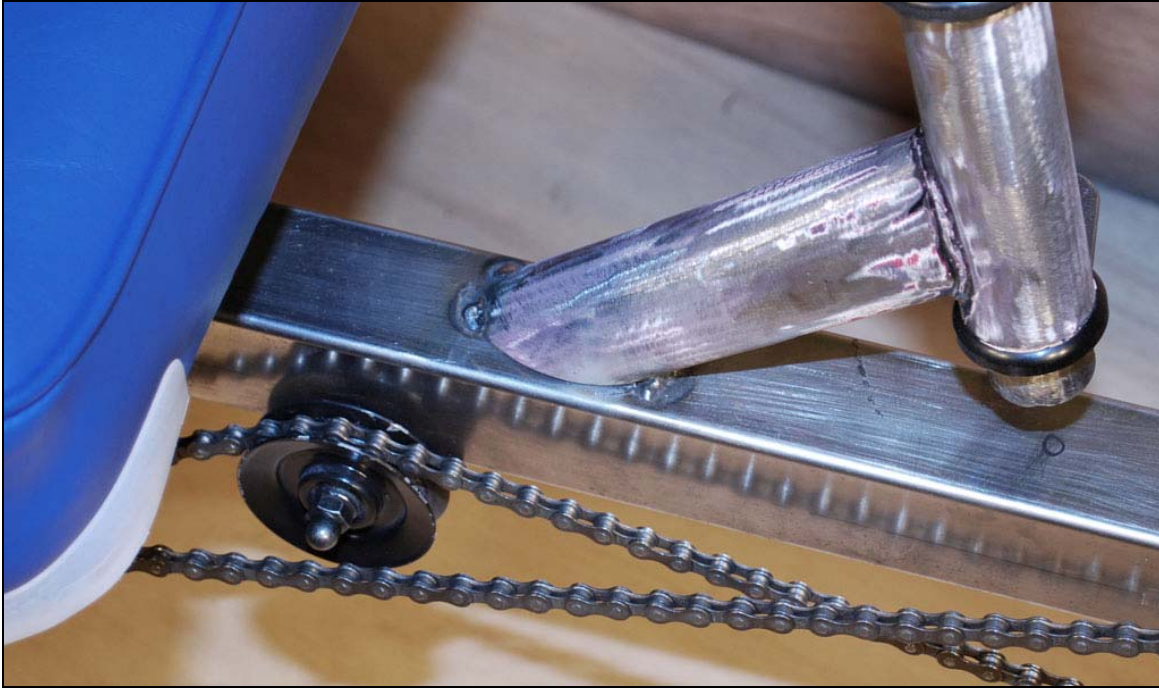


Figure 146 – Tack welding the steering assembly to the frame

When you have fooled around with different handle bar styles and positions and found something you like, have your helper mark the down tube so it can be cut to the appropriate length. Remember to keep the pilot's head tube angle almost the same as the front head tube so that the steering linkage will make a straight line to the front forks. As shown in Figure 146, the down tube has been trimmed and the pilot's steering system is tack welded in place.

While making the pilot's steering parts, keep in mind that the fork stem and lower bearing hardware must first be installed in the head tube before you weld the parts to the frame as the fork stem can never be fully removed because the frame boom will be in the way. This is done on purpose, and is not a problem because you can still grease the fork hardware once installed. Since these bearings will never carry any load, the chance of ever needing to replace them is almost zero. If you do need to replace the bearings, only the lower one will be fixed, but you could simply grease the lower cup and feed the balls in place manually.

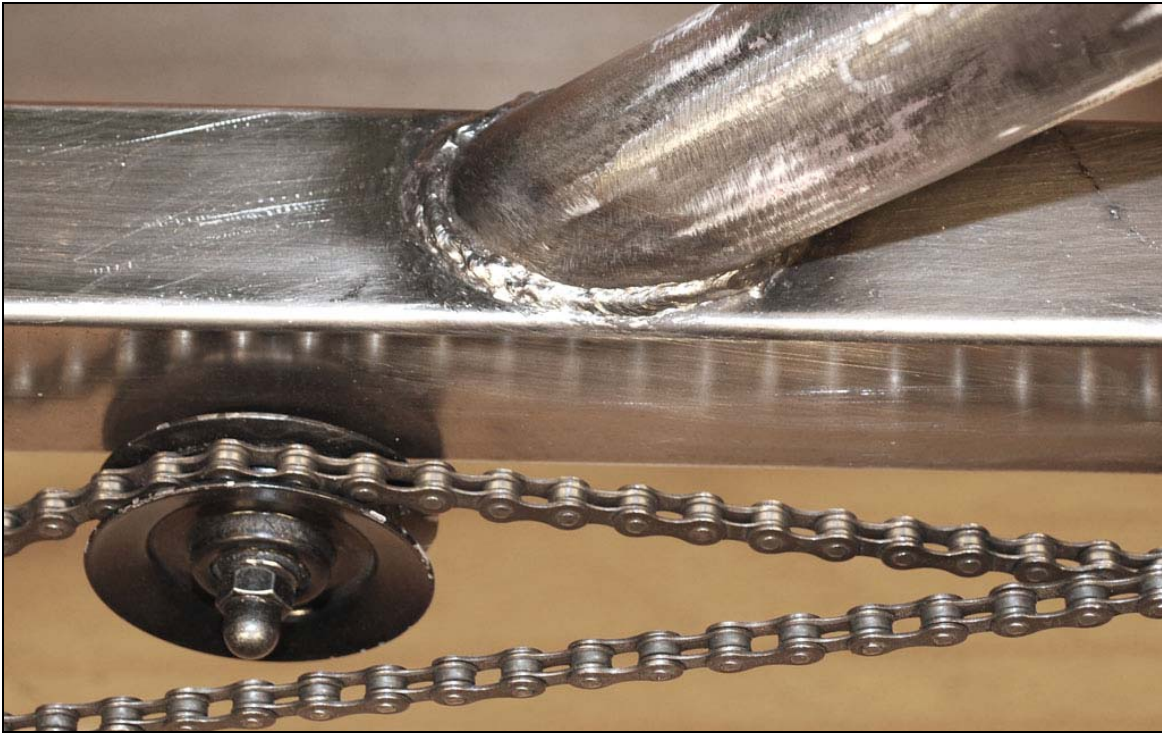


Figure 147 – Down tube completely welded

The pilot's head tube assembly is welded to the chosen position on the frame as shown in Figure 147. The pilot's head tube and front head tube should be within 5 degrees or so of each other in order to make the linkage work properly. Follow the usual order of welding operations.

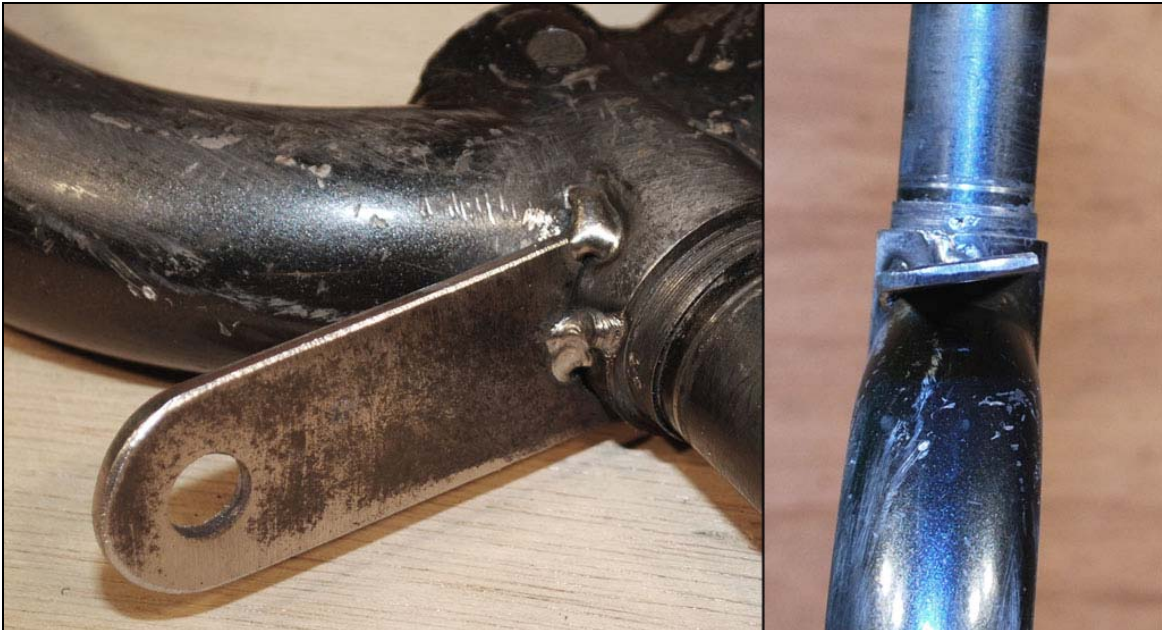


Figure 148 – Fork control arm installation

Tack weld the front fork control arm to the fork crown as shown in Figure 148, much like it was done on the pilot's fork stem. For starters, use a large tack weld in the center, as you might need to tweak the angle of the control arm later. As shown on the right of Figure 148, the control arm is on a slight angle so that it points toward the pilot's control arm. This slight angle helps make a straight line from one control arm to the other, and will keep the ball joint bodies from rubbing on the control arm surface.



Figure 149 – Fork control arm welded

I don't recommend that you complete any of the welds on the steering parts until it has been tested. If you find that the ball joint body rubs on the control arms, you could easily bend them slightly with a large wrench. When you do finish the steering control arms welds, ensure that the joints are well done all the way around as shown in Figure 149, as you would not want these welds to fail!



Figure 150 – Installing the control rod

The control rod is a length of $\frac{1}{2}$ inch hollow rod that allows the ball joint bolt to be welded inside as shown in Figure 150. Normally, I would weld nuts on the end of the control rod so that the ball joints can be screwed in for fine adjustments, but in this design it is not really necessary.

To get the control rod to the perfect length, just place your front forks and pilot's steering system in the "straight ahead" position, and then measure the distance between control arm bolt holes. Now you know how far apart the ball joint bolt holes need to be. For any fine tuning, you can simply move the gooseneck in the pilot's steering tube.

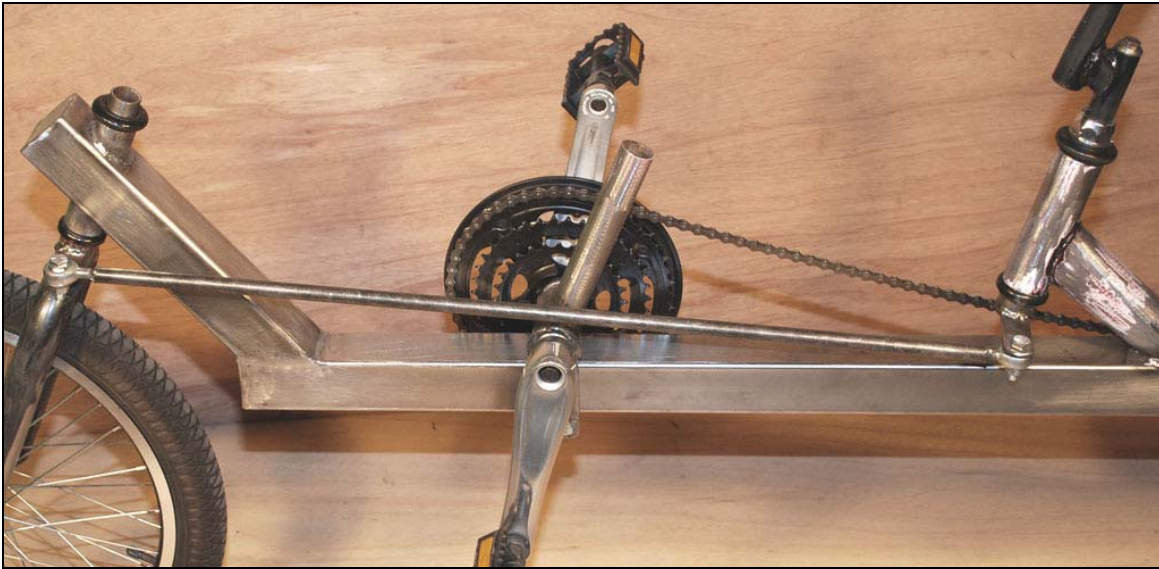


Figure 151 – Control rod installed

Figure 151 shows how the control rod joins the front forks to the pilot's steering system once installed. Now you can see why the control rod needs to be on the left side of the frame. Your steering system should have a good range of motion, and the ball joints should not rub on the control arms. A few washers, or slight bending of the control arms can cure any small rubbing problems.



Figure 152 – Pedal clearance is fine

The control rod will sneak in between the frame and crank arm as shown in Figure 152 once installed. Don't worry about how close the control rod may be to the crank arm, as your foot can never enter this space.



Figure 153 – Testing rang of motion

Figure 153 shows the massive amount of turn the wheel will have in both directions. With this amount of steering, the LodeRunner will be able to make nice small turning circles and will be highly maneuverable. When you lock down the ball joints, use quality bolts with plastic lock nuts.



Figure 154 – Installing the front derailleur

The front derailleur can now be installed so you can mark a line and trim off the extra shifter tubing. As shown in Figure 154, the derailleur sits slightly above the chain ring, and I had about two extra inches of material that could be removed.



Figure 155 – Capping off the open tube

With the derailleur tubing cut to length, it is a good idea to cap off the open end of the tubing so that it looks better and keeps any moisture out. As shown in Figure 155, a washer is welded over the end of the tube and then completely filled in around the joint and the hole. To fill in the washer hole, several passes are made around the edge until completely covered in weld metal. Capped tubing looks so much more professional and will not leave any dangerous sharp edges or holes for bugs to live in.

Installing Lights



Figure 156 – Adding lights to the frame

Before painting, you might want to consider things like lights or even a trailer hitch. I decided to install one large headlight and a pair of flashing red rear lights as shown in Figure 156. Having a pair of lights on the rear corner will let drivers know how wide you are at night. The light will be held to the frame using the pieces of flat bar also shown in Figure 156.

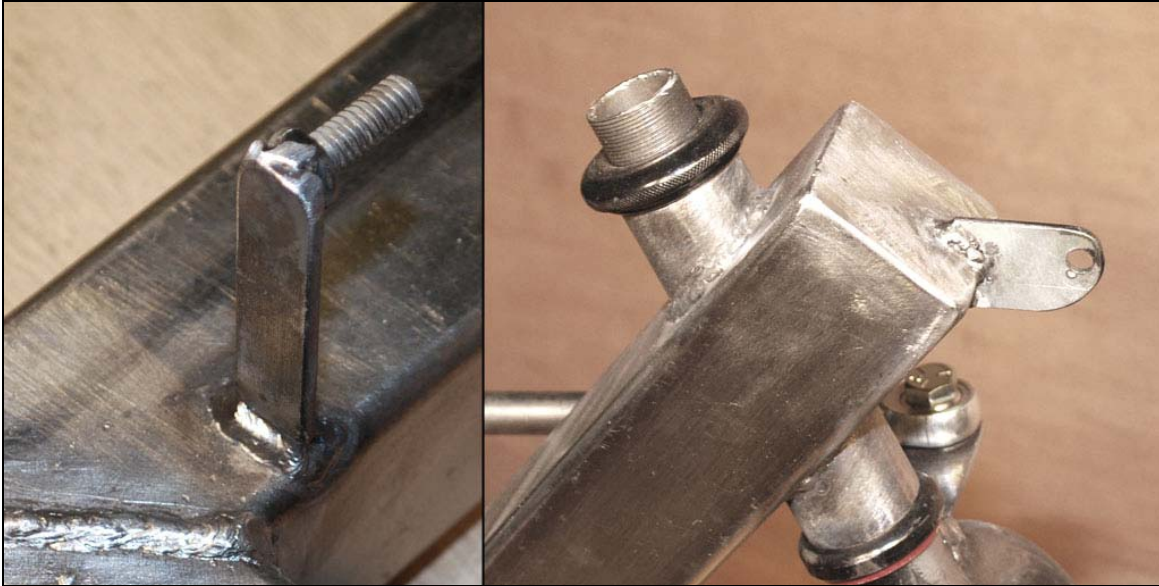


Figure 157 – Light mounting tabs installed

The front of the frame makes a great place to mount a headlight as shown in Figure 157. The rear lights are held on by the bolts that are welded to the two small pieces of flatbar.

Priming and Painting



Figure 158 – Primed and waiting for paint

The completed frame now gets one last check for ugly welds and then get a light sanding to help primer adhere to the metal. All of my painting is done using only \$5 spray cans out in the backyard, but like all things, follow the instructions and take your time and your paint job will look great. The primed frame shown in Figure 158 gets to sit overnight to dry before painting.



Figure 159 – We got the blues!

The completed and painted LodeRunner is striking a pose in Figure 159 – not bad for a back yard paint job! Avoid the temptation to assemble the parts before the paint has cured for a day or two or the finish will scratch very easily. Paint should actually cure for more than a week to withstand small scratches and dings, but that kind of waiting can really try one's patience!

All bearing should be greased, and all bolts should have plastic locknuts, especially the steering parts. Now on to the cabling.

Installing Brake Cables



Figure 160 – Adding all those cables is a chore

Cabling a new bike or trike is a bit of a chore, but if done properly will only have to be done once. I really don't enjoy running cables all over the place, but this is a necessary evil that has to be done, so take your time and plan ahead before cutting any cable to length or adding any zip ties. Avoid any sharp bends in any cable, ensure the front wheel and handlebars can turn from side-to-side without putting a cable under great tension, and always replace any rusty, frayed or stiff cables with new ones.

The brakes need to be fine tuned so that they don't rub when not in use, but at the same time grip the rim with optimal power when the lever is fully engaged. Each brake lever has an adjustment screw, and it should be screwed all the way in when you initially set up the brakes. If the brakes don't grab hard enough, slowly turn the lever adjustment screw counter clockwise to stiffen up the brakes. A tiny bit of brake rubbing is OK as long as you can spin the wheel freely.

There are as many styles of shifters and levers as there are cycles, so you may have to do some shopping or scrounging to find ones you like. My personal favorite has always been the old style road bike levers shown in Figure 160. These shifters always work, are easy to find new and used, and fit perfectly on the long gooseneck. These shifters are “analog”, meaning that they do not click

from one gear to the other – you just keep pulling the lever until you are in the gear you want. Indexed shifters are nicer, but much more finicky to get set up, so I almost never use them.

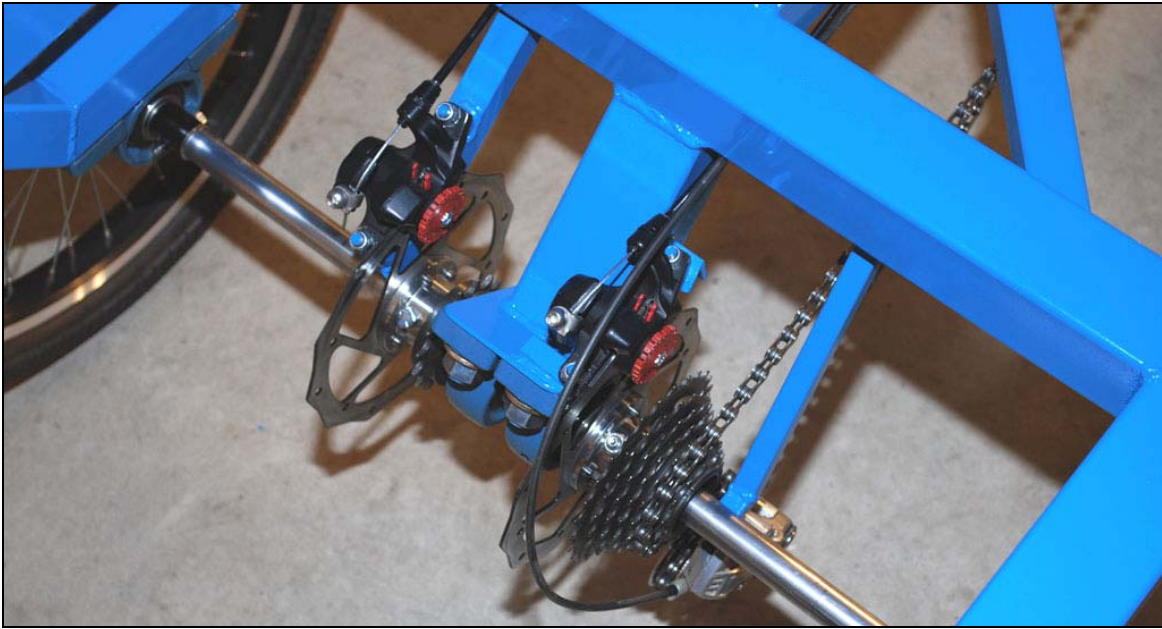


Figure 161 – Disc brake cables installed

The disc brakes should be set up so they have almost no friction until the lever is engaged. Although the brakes may rub slightly on the discs when they are relaxed, the wheels shouldn't stop until the lever is depressed at least 25 percent of the way. The brakes and the levers have adjustment screws at the cable ends that will help you adjust the tension. Figure 161 shows the dual disc after adding the cables and adjusting them.



Figure 162 – The bare bones LodeRunner

The completed LodeRunner shown in Figure 162 is a beautiful and sturdy machine. Not bad considering that it was made using only recycled bicycle parts, steel tubing and a small machined part. A similar quality trike would easily cost you thousands, and might not have the strength that your home built unit does. The only unanswered question is what will you do with that cargo space? The options are almost endless, but the obvious thing to do would be to drop on a simple box with a lid so you can haul your groceries. The next few steps will show you how to make a lightweight and simple box that can be easily removed from the frame.

Building a Cargo Box



Figure 163 – The cargo box frame parts

A nice multipurpose cargo box can be made by chopping up some half inch angle iron as shown in Figure 163 to form a frame. I decided to make my cargo box the same size as the frame box and add a sloped top. The top and bottom of the box will have half inch plywood for strength and the sides will have $\frac{1}{4}$ inch plywood to save on weight. The parts to make the box frame are shown in Figure 163.



Figure 164 – Cargo box base completed

The base frame for the cargo box is shown in Figure 164. The frame is 21.75 inches square, and the plywood base is slightly smaller than the frame so

that the plywood walls can fit between it and the angle iron.

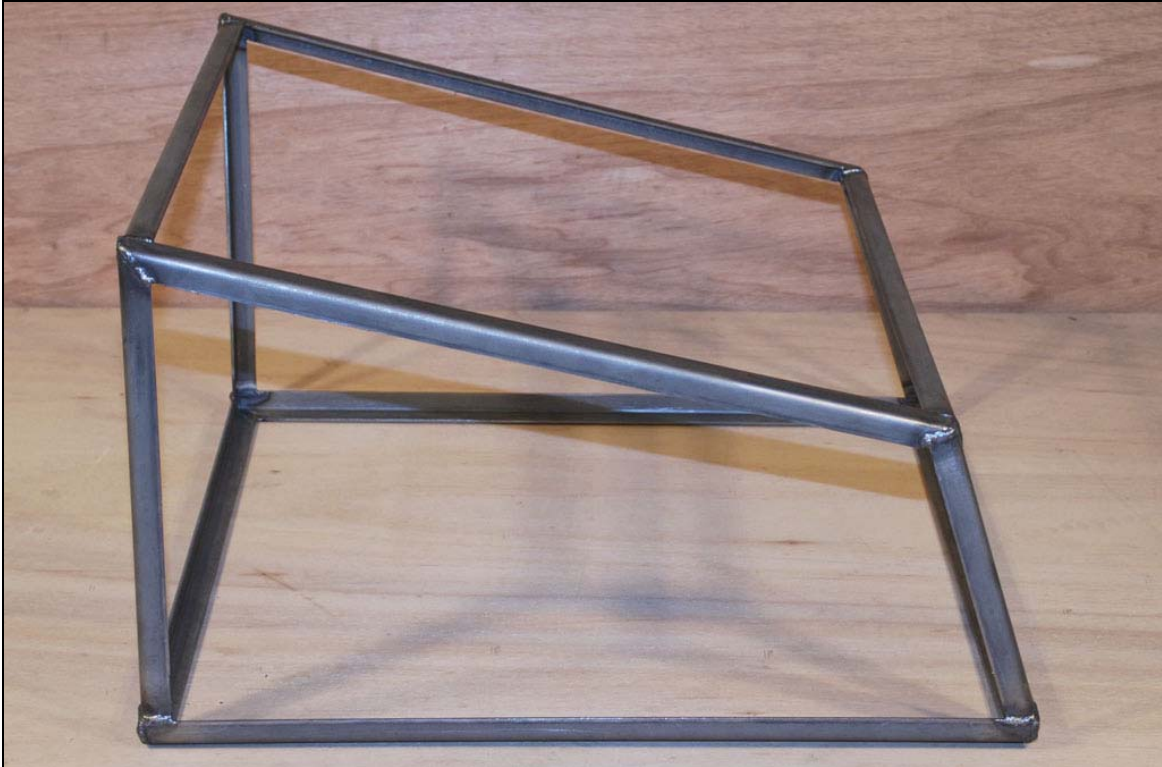


Figure 165 – Making the side walls

Rather than a boring looking square box, I decided to make the rear of the box 8 inches tall and the front of the box (behind the seat) 12 inches tall. This configuration looks more pleasing, and is a bit more aerodynamic. Figure 165 shows the basic box frame welded together.

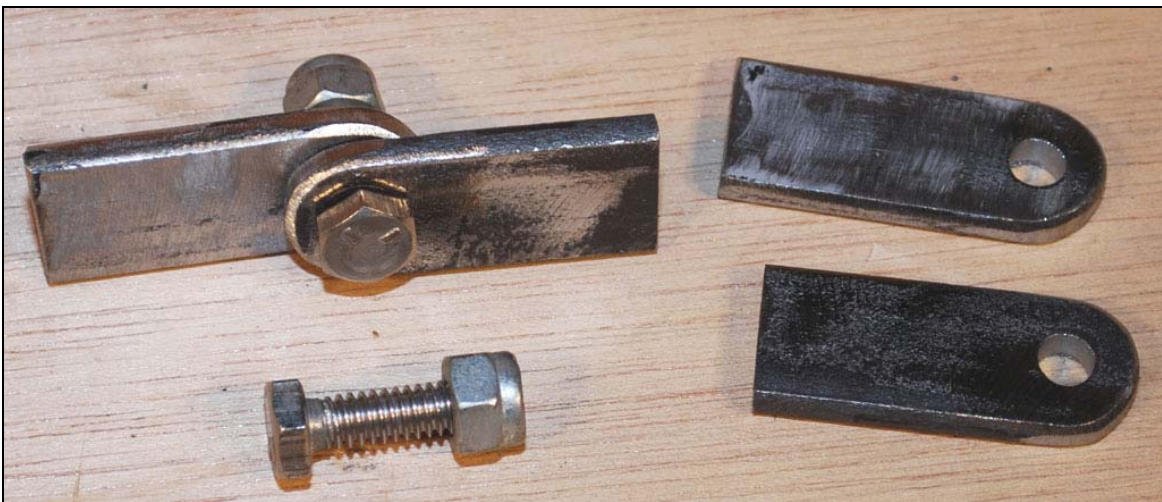


Figure 166 – Making a lid hinge

Since I made everything on the LodeRunner by hand so far, why stop now? A pair of strong lid hinges can be made using a pair of bolts and some flatbar as shown in Figure 166. You could weld a hardware store steel hinge to the lid, but I will warn you – it will rattle like crazy when you hit bumps. This hinge will not rattle.



Figure 167 – Adding the cargo box lid

The cargo box lid is just another angle iron frame as shown in Figure 167, attached to the box top by the home brew hinges. This simple steel frame cargo box is almost as light as those plastic tool boxes, but much stronger.



Figure 168 – Cargo box mounting tabs

I wanted to be able to remove the cargo box and swap it with other types of boxes or boards, so made a few mounting tabs from more angle iron. Figure 168 shows the underside of the cargo box, which now has four tabs to allow it to bolt onto the frame. A few machine screws will hold the cargo box to the frame once I drill holes on the inside of the frame box.

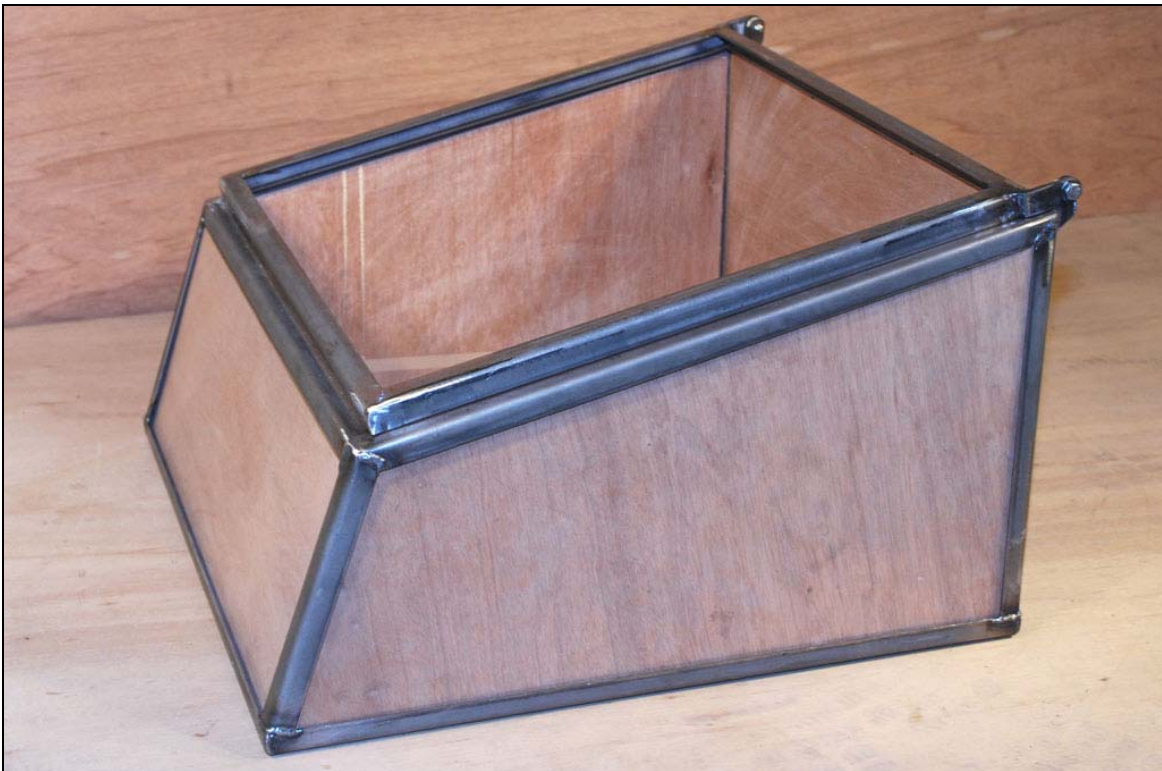


Figure 169 – Completed cargo box

The completed cargo box is shown in Figure 169 with the top board not yet in place. The box only weighs 12 pounds, but is strong enough to sit on top of, and will carry just about anything you can cram into it. Because the hinge is held together by bolts, the lid can be removed to allow other cargo like kids or pets to tag along for a ride.



Figure 170 – Cargo box installed

The completed and painted cargo box is shown installed on the LodeRunner in Figure 170. This simple box looks a lot better than a plastic storage container or a tool box, and is a lot stronger as well. I have also left a decent sized space between the cargo box and the seat so a tray of four gel batteries can be installed once I decide to add a front hub motor. A 500 or 600 watt front hub motor and a 48 volt, 20 amp hour battery pack will run your trike all day at speeds comparable to motorized vehicle speeds on urban streets. Don't worry, you still get to pedal with a hub motor, but you will be able to rocket up huge hills even with a full cargo box.



Figure 171 – Loaded with groceries

How much cargo can you jam into the trunk? Well there is almost a full cart of groceries being hauled home in Figure 171. Add a trailer, and you could carry as much cargo as a small car – maybe even a small car! Now I have no excuse for not getting exercise or wasting gasoline for nothing. My bike really is an SUV!

Thanks for your support, and we hope your build progresses smoothly. With a little patience, a pile of scrap bicycle parts, and some trial and error, you can create just about any human powered vehicle imaginable. There is plenty of room for modification on the Marauder, so please send us your completed photos for the [Builder's Gallery](#) so that others can see what you have done. If you need any assistance or want an opinion on an idea, stop by our [Support Forum](#) and introduce yourself to our many creative fellow garage hackers.

Good luck on all of your projects. Have fun and ride safely.

Brad Graham and Kathy McGowan
Atomic Zombie™ Extreme Machines